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WILFRED HUDSON OSGOOD: 1875–1947

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To Marion Hudson Osgood and Harriet Amanda Osgood was born on December 8, 1875, a son in Rochester, New Hampshire. He was their first child and was named Wilfred Hudson Osgood.

In 1888, the family, now with five children, Wilfred, Alice (Mrs. Alice M. Gay), Sumner, Hattibel, and Marion (Mrs. Kenneth Dowie) went to California, settling in the Santa Clara Valley.

His brother, Mr. C. Sumner Osgood of Torrington, Connecticut, has written me concerning these early days that "We lived in the Santa Clara Valley when the family removed to California from New England in 1888. My father and my uncle, who was living with us, purchased a thirty acre fruit farm three miles from the village of Santa Clara. Wilfred was then twelve years old. He attended the district school near "Milliken's Corners," and at once began to range the countryside in search of adventure—sometimes birds' eggs, sometimes watermelons from the patch of an unsuspecting neighbor. Rochester, N. H. had been a small New England town, but here he was having his first taste of a strictly rural situation. It was only a short time later that the orchard was sold as an unprofitable venture for New Englanders, and the family moved to Santa Clara. During the three years there he attended high school. In his graduating class was Chester Barlow, who later became one of the charter members of the Cooper Ornithological Club. It was after the family had moved to San Jose that this club was organized, and if I remember rightly the organization meeting was held in the living room of our home. . . . During his early years in San Jose he was an enthusiastic collector of birds' eggs. He made a large cabinet with a tier of drawers for storing his collection, and his friends used to gather and "talk shop" with him. On one occasion he and his companion Beck (Rollo H. Beck) made a trip to the Farallone Islands as a sort of business venture. They collected hundreds of murres' eggs, and shipped them to San Jose in boxes. (I was enlisted in the fragrant job of "blowing" these eggs, which were then offered for sale to collectors.) Somewhat later this friend Beck made a trip to the Galapagos Islands, and brought back quite a number of the giant turtles, and I know that Wilfred was much interested in this venture also."

After graduating from high school, Dr. Osgood taught in a small school in Wilcox, Arizona, for a year to earn money for his college work. He entered Stanford University in one of the earliest classes, perhaps in the pioneer class. He knew Herbert Hoover, who was in this first class at Stanford.

In 1899, he received his A. B. degree from Stanford although at this time he was with the Biological Survey in Washington. Concerning this, his brother has written me, "While at Stanford he came under the influence of Dr. Gilbert, the head of the Department of Zoology, and of David Starr Jordan, the president. It was at Dr. Jordan's suggestion and recommendation that he left college before finishing his senior year to take the position in Washington." Among the last entries in Dr. Osgood's journal on the Mt. Shasta expedition are the following, "Oct. 12, 1898—Went to Palo Alto and had a great time seeing the boys. Gilbert thinks I can get my degree without spending any time here." And again, "Oct. 14, 1898—Went to Palo Alto again. Put in a petition to Dr. Elliot for permission to finish my work in Washington."

That his formative years in Washington were greatly influenced by his association with C. Hart Merriam, there can be no doubt. He not only worked under him in the Survey, but lived at his house where he met many of Merriam's friends and especially was associated with the geologist, Grove K. Gilbert, who also made his home with Merriam for many years.

In Dr. Osgood's Biographical Memoir of Merriam can be seen how well he knew him, both his best qualities and his faults, and undoubtedly he profited from both in later life. His training in carefulness and thoroughness must have been largely due to Merriam. He was certainly encouraged and aided by him in his first two revisionary papers on *Perognathus* and *Peromyscus*. Dr. Osgood was one of "Merriam's men" and continued in a broader sense with his work and ideas.

While at the Field Museum of Natural History in Chicago, he received his Ph. D. from the University of Chicago, in 1918, his thesis being "A Monographic Study of the American Marsupial, *Caenolestes*."

Dr. Osgood made three trips to England and Europe to study collections there. The first was in 1905–6. In his "Revision of the Mice of the American Genus *Peromyscus*" (p. 10), Dr. Osgood states concerning specimens examined "also important specimens belonging to European institutions especially the British Museum." In another reference (Jour. Mamm., 26: 441, 1945) to this trip, he said, "A number of years ago (1906), by considerable effort and some expense, I visited European museums and made a careful examination of various specimens forming the basis of early descriptions of certain North American mammals. The object was to eliminate, so far as possible, the personal equation in interpreting the descriptions of authors who did not designate types and who frequently confused several species or subspecies as later understood."

These remarks make the object of the trip clear, but whether Dr. Osgood was sent by the Survey or paid his own way has not been discovered. His reference to "considerable effort and some expense" seems to infer that he had at least in part financed the trip.

On coming to Field Museum in 1909 he was sent to the British Museum (Natural History) in London with the collection of mammals made by Akeley and Heller in Kenya Colony in 1905–6. He remained in London about three months identifying this material. In 1930, Dr. Osgood returned to London to identify

the collection of Indo-Chinese and Chinese mammals collected by the Kelley-Roosevelts Asiatic Expedition.

On these trips he became personally acquainted with the British mammalogists Thomas, Hinton, Pocock, Dollman, and others. He thought a great deal of Thomas, both personally and as a mammalogist, and on hearing of his death sadly remarked that the British Museum would not be the same place without him.

Dr. Osgood held but two positions during his lifetime. He was with the Bureau of Biological Survey, U. S. Department of Agriculture, Washington, D. C., as Assistant Biologist for twelve years from 1897 to 1909. He then came to the Field Museum of Natural History (now the Chicago Natural History Museum) in Chicago where he remained until his death. Here he held posts as Assistant Curator of Mammals and Birds 1909–1920, Chief Curator of Zoology 1921–1941, and Curator Emeritus 1941–1947.

He grew with the Museum and developed the Department of Zoology to what it is today. He came after Dr. D. G. Elliot and Carl Akeley had had charge of the mammal collection for some years. Each had kept his material separate, study skins belonging to Elliot and material for exhibition kept in Taxidermy by Akeley. These were now brought together in one catalogue, the same number placed on both skin and skull instead of a different one for the skull; original labels were kept on the skins instead of being filed, and, in all, the care of the collection was placed on a more modern footing. He also saw that the actual date of publication appeared on the papers printed by the Museum and had added to the library many important books and serials.

Dr. Osgood not only placed operations on a practical basis while in the old building, but was largely responsible for the forming of the Zoological Staff and especially for the plans for enlarged exhibition when the Museum opened its present building in 1921. There were but four members on the Zoology Staff in 1921 compared with fifteen and twelve Research Associates in 1947.

One of those selected by Dr. Osgood for the Staff was his old friend, Edmund Heller, for Curator of Mammals. He had first been associated with Heller at Stanford and in the Cooper Club in its earliest days. He took Heller to the Queen Charlotte Islands and Cook Inlet with him on his second Alaskan trip. Curiously enough, Dr. Osgood replaced Heller in the Museum at Chicago and started to work on Heller's African collection. Heller had wanted to identify this collection himself, but instead went to Africa with Roosevelt and made another collection which he did report on. Dr. Osgood was always a very staunch friend of Heller's and never failed to extoll him as one of the greatest of field collectors.

In 1926–1927 there were seven zoological expeditions in the field, each of which had, in some part, come under Dr. Osgood's supervision. During his term as Chief Curator, fifty-three habitat groups of large mammals were added to the exhibition series. These included three new halls, one of Asiatic mammals, one of marine mammals, and one of whale models. The synoptic series of mammals was also renovated and reinstalled. Besides mammal exhibition, Dr. Osgood

had the responsibility of overseeing the installation of seventeen bird groups, six fish groups, and two reptile groups, and the entire renovation of the synoptic series of birds. The planning and supervision of the large exhibition program occupied a large part of his time. The research collections increased enormously during these years, mainly through expeditions. With all this, Dr. Osgood still found time to edit all the zoological publications, continue his research, and to go on five major expeditions. On his retirement in 1941, the Museum published a Testimonial Volume to him comprised of eleven papers on mammals by some of his colleagues and members of the Museum Staff. Mr. Stanley Field, President of the Museum, says of him in a review of his work in this volume, "The great growth of Field Museum has coincided with Dr. Osgood's regime as Chief Curator of Zoology. This growth has been twofold: in the direction of exhibition on one hand and in the development of the scientific collections and of the researches based on them on the other. No one in Field Museum's organization has played a more active or more effective part in this vital development period of the Museum than has Wilfred Hudson Osgood."

EXPEDITIONS

During his adult lifetime, Dr. Osgood made thirty collecting trips, some of but a few weeks, others of almost a year. While with the Biological Survey he was sent five times to Alaska, and once each to California, Utah, Maine and Canada, and western United States. His foreign trips for the Museum included six to South America, one to Africa, and one to French Indo–China. Besides these, there were twelve short trips to various parts of the United States and Mexico, and one return to Alaska for the Government on seal investigation in 1914.

Dr. Osgood's first professional field work was a trip (Pl. I) in the Mt. Shasta and Mt. Lassen area, from July to October 1898, in company with C. Hart Merriam, Vernon Bailey, W. K. and R. T. Fisher, and Lyman L. Merriam. His younger brother, Sumner Osgood, went as cook. During the summer the party was visited by John H. Sage. The material collected was reported on by Merriam in North American Fauna No. 16. Two of the mammals collected by Osgood were described as new.

The next year, 1899, he made his first visit to Alaska and was in charge of the trip. He was accompanied by Dr. Louis B. Bishop as voluntary companion and Alfred G. Maddren as assistant. They went from Skagway over the White Pass to Lake Bennett at the headwaters of the Yukon. Here they built a flat-bottomed boat, eighteen feet long with a five foot beam, of cedar and spruce and sailed it down to Circle. The party separated here and Bishop left by steamer for St. Michael while Osgood and Maddren went in a small boat purchased in Circle. In trying to tie to a snag on the bank, the boat was drawn under and capsized, throwing them both in the icy water. Osgood caught hold of a wooden chest of specimens as it floated by. The boat, soon torn loose by the current, was carried past them bottom side up and they managed to swim to it and each get an arm over it. After being carried along for half a mile, they struck a log jam at the tip of a small island where they managed to get ashore, but the boat

was carried under and disappeared. All they could see of their duffle was a duck that had been lying on the bottom of the boat. It was caught in a crotch of a submerged tree in a very swift current some thirty feet from shore, and impossible to reach.

After getting a fire started with one dry match, eating wild rose fruit and a handful of wet oatmeal, they burned some drift logs into lengths and made a raft, finishing late at night. The next morning they found their boat had caught in a log jam and were able to retrieve it and also get the duck, which they had for

PLATE I

Osgood at Mt. Lassen, California—1898

breakfast. Resuming their journey, they were picked up two days later by a passing steamer and taken to St. Michael. The results of this trip appeared in North American Fauna No. 19. Ten new mammals were described from the fifty-four species collected.

In 1900, the Survey again sent Osgood to Alaska, this time to collect in the Queen Charlotte Islands and Cook Inlet. He took with him his friend of the Cooper Club, Edmund Heller. The report on the trip was published in North American Fauna No. 21 the next year.

The late summer of 1901, from August 24 to November 1, was spent investigating prairie dog colonies in Kansas, Nebraska, North and South Dakota, and Montana. On this trip Osgood met Otto Widman, Merritt Cary, and J. D. Allen for the first time. His journal describes prairie dog towns of from two acres to six or seven hundred acres. He experimented with many kinds of poison and

PLATE II

Osgood in Abyssinia—1926

gas as means of exterminating them, but nothing seems to have been published concerning these investigations.

In 1902, a trip extending from July to November covered the base of the Alaska Peninsula. He was accompanied by Alfred G. Maddren as assistant and Walter Fleming as camp hand. Mr. W. Gorman, botanist for the Department, accompanied them for part of the trip. The route covered Lakes Iliamna and Clark, the Chulitna River and Nushagak River to Nushagak, across Bristol Bay, up the

Ugaguk River to Becharof Lake, across the mountains to Kanatak, and by open boat to Cold Bay. This last leg was almost disastrous as the boat was caught in a sudden storm and nearly capsized. It was a very arduous trip with much rain and wind. The report appeared in North American Fauna No. 24.

The summer of 1903, from May to October, was spent with Mr. Ned Hollister collecting on the Yukon River between Eagle and Circle, Alaska, and at the head of Seward Creek under the brow of Glacier Mountain. From Dr. Osgood's journal, this appears to have been a much pleasanter trip than some of his others to Alaska as they were not exposed to so much rain and bad weather. It was also the beginning of a long friendship with Hollister.

In 1904, two trips were made. The first tying in with the work in 1903, covered Coal Creek in the Ogilvie Range, and the second on the MacMillan River. The party of the first trip consisted of Dr. Osgood, Mr. Charles Sheldon, and the well known artist, Mr. Carl Rungius. On the second trip they were joined by Mr. Frederick C. Selous of England and a number of citizens of Dawson. The party was divided into three sections and Dr. Osgood hunted with Mr. Rungius for about two months. His full report on these two years' work appeared in North American Fauna No. 30.

On his return from Europe he was sent, in 1907, into Maine and the Maritime Provinces of Canada to study the methods of silver fox farming. The results of his investigations were published in Farmers' Bulletin No. 328—Silver Fox Farming.

His last trip for the Survey was through southern Utah from August to October 1908. He described a new *Sorex* from this collection and years later Goldman described a new subspecies of *Thomomys* from it. This ended his work with the Survey as in 1909 he came to Chicago and started on a new field of study.

From 1909 to 1947, while associated with the Field Museum of Natural History, later the Chicago Natural History Museum, Dr. Osgood went on eight major expeditions outside the United States. Those covered six to South America, one to Africa, and one, financed by himself, to French Indo-China. Besides these, he collected on twelve other local trips, mainly vacations or hunting trips in various parts of the United States, Canada, and Mexico.

His first trip was to Venezuela and Colombia in 1911 with Stanley G. Jewett, Sr., where collecting was carried on in the Lake Maracaibo region and on the highlands south of it. This was the beginning of years of collecting and study of South American mammals. Eleven new mammals were described from the collection.

In 1912, accompanied by Malcolm P. Anderson, an important trip was made across northern Peru, an almost untouched area at that time. From the coast at Pacasmayo they went inland through Cajamarca, Balsas, and Chachapoyas to Moyobamba, thence by foot to Balsa Puerto and so by canoe to Yurimaguas and thence by steamer down the Amazon. About 2000 birds and mammals were collected and sixteen of the mammals were described as new.

There now came a lull of about eight years, due in part to unsettled conditions brought on by World War I. During this time, many new exhibition labels were

prepared by Dr. Osgood and a card index of the mammal collection was made. Packing collections for removal to the new building and plans for their installation began in 1918 and occupied nearly four years.

In 1914 Dr. Osgood served for six months on a Government commission to study and make recommendations for the management of the fur seals on the Pribilof Islands.

With Mr. Boardman Conover, Dr. Osgood made another trip to Venezuela in 1920, working around Lake Maracaibo and the Sierra de Perija for some five months.

On Dr. Cory's death in 1921, Dr. Osgood was made Curator of the Department of Zoology, and with the opening of the new building began a new era in the history of the Museum with large exhibition and expedition programs.

In November 1922, Dr. Osgood led the Marshall Field Chilean Expedition accompanied by Mr. Boardman Conover and Colin C. Sanborn. After some months in southern and central Chile, Dr. Osgood collected around Buenos Aires and Tucuman, Argentina, returning to Chicago in July 1923.

Three years later he led the Field Museum–Chicago Daily News Abyssinian Expedition (Pl. II) which was in the field from November 1926 to April 1927. Other members of the expedition were Louis A. Fuertes, Alfred M. Bailey, Suydam Cutting, and Jack Baum. No complete report was published on the mammal collection, but a number of new forms were described in two short papers. "Artist and Naturalist in Ethiopia," the combined diaries of Dr. Csgood and Louis Fuertes, giving their impressions and notes for each day, was compiled by Dr. Osgood and gives a very complete history of the expedition.

In 1937, he went alone to French Indo-China on an expedition financed by himself. He made large collections of mammals and collected specimens for a group of gibbons and for one of pea-fowl. He was in the field from February to April.

Ever since the Chilean Expedition of 1922, Dr. Osgood had been awaiting the opportunity of returning to Chile to collect in the Magallanes area and on Tierra del Fuego, besides visiting places missed on the previous expedition. This became possible in 1939 when the Magallanes Expedition was arranged. Dr. Osgood was joined on his steamer in Peru by Colin C. Sanborn and John M. Schmidt and the party continued to Chile. About three months were spent traveling on Tierra del Fuego and in the Magallanes region in the expedition truck and the first comprehensive collection of mammals from the region was made. While Dr. Osgood suffered a few digestive upsets, on the whole his health was good and he fully enjoyed the trip.

His last foreign expedition was in January–February of 1941 when he was a member of the Mandel Galapagos Expedition which traveled on the yacht "Carola" to the Galapagos and made a short stop at Talara in northern Peru.

His mammal collections totaled 7531, about half for the Biological Survey and half for the Chicago Natural History Museum.

SCIENTIFIC WORK AND PUBLICATIONS

Dr. Osgood's first contribution to natural history was published in the Oologist in 1892 when he was seventeen years old. While his work with the Biological Survey took him repeatedly to Alaska and he prepared four reports on these trips, it is significant that his thirteenth paper was a revision of the pocket mice of the genus *Perognathus*, and this was followed a few years later by his revision of the genus *Peromyscus*, showing an early interest in rodents and a realization of the need for generic revisions. His early publications naturally dealt mainly with these two genera and with the natural history of Alaska.

Of all his scientific works, Dr. Osgood is probably as well known for his work on *Peromyscus* as any other. While other revisions had appeared in the Fauna series by others on the Survey, it was one of the largest dealing with more forms and a greater number of specimens, about 27,000. It has stood as a pattern for future workers and today remains with few changes as the only revision of the genus. This widespread North American genus with its large number of races has naturally interested the geneticists who make continued reference to this revision.

His first work at Chicago was the identification of Heller's and Akeley's Kenya collection, but with this out of the way, he started on South American mammals which became his main interest. During his work at Chicago, forty-nine (one-quarter) of his publications dealt with South and Central American mammals and their nomenclature. These included the "Monographic Study of the American Marsupial, *Caenolestes*" and the "Mammals of Chile." An example of Dr. Osgood's thoroughness is that while he had the "Mammals of Chile" practically completed by 1926, he would not publish it until he could get material from Magallanes and Tierra del Fuego, so he waited thirteen years for the opportunity to complete the Chilean collection before he would publish the work in 1943. He left an almost complete card file of the mammals of South America that was being prepared for publication at the time of his death.

His South American research was interrupted by the preparation of the report on the mammals of the Kelley–Roosevelts and Delacour Asiatic Expeditions and a report on some of the more important rodents from three African expeditions.

A total of fourteen new genera and subgenera and 263 new species and subspecies of mammals were described by Dr. Osgood, and thirteen mammals, three birds, one toad, two fishes, and one plant were named for him.

It is remarkable that he was able to do as much research as he did with the load of administrative work he carried at the same time, which included the editing of the publications of the Department of Zoology.

CLUBS AND ASSOCIATIONS

From the first, Dr. Osgood took a leading part in the scientific societies. His first office was President of the Cooper Club in 1893, followed by Treasurer in 1894, and Vice-President in 1896. During his stay in Washington he was Record-

ing Secretary of the Biological Society of Washington from 1901 to 1904 and Corresponding Secretary from 1905 to 1909.

When the American Society of Mammalogists was formed, he served as Vice-President from 1919–23 and as President from 1924–26. He also served for long periods on the Bibliography, Conservation, and Nomenclature Committees. He was a Trustee of the Chicago Zoological Society since 1933. The American Ornithologists Union elected him as Associate in 1893, a Member in 1901, and a Fellow in 1905. In other groups he was a Member of the British Ornithologists Union; Corresponding Member, London Zoological Society; Member, Division of Zoology, National Research Council; Geographic Society; Boone and Crockett Club; Explorers Club; and University Club of Chicago. He remained a bachelor and during his years in Chicago lived at the Quadrangle Club of the University of Chicago He served one term as President of the Club.

During the twenty-five years that it was my great good fortune to be associated with and trained by Dr. Osgood, it was his character of carefulness and thoroughness that was perhaps the most impressive. This may have been inherited from New England ancestors or it may have been acquired on his early hazardous expeditions to Alaska where he had a number of very narrow escapes. He did not seek adventure as such and repeatedly stated that expeditions were hard work and not adventures. A motto he gave me and which he must have followed was, "Be sure you are right and then look again."

In his research and writing he was particularly careful, and at times, it might be said, even over-cautious. Because of this, others sometimes got ahead of him, but his record of accuracy has proven this trait a good one.

Dr. Osgood in the Museum and in the field was two different people and no one knew him until they had seen both of these sides. Administrative duties and a press of work were more apt to bring on an attack of the stomach trouble that so long plagued him and which made him seem preoccupied. He greatly enjoyed field work and on an expedition he was always in better health, almost carefree and much happier. This, however, was only a change in the outward man. The inner man never changed, and in the Museum or in the field Dr. Osgood was always helpful, generous, and considerate. When first with him in the Museum he sent me with a request to one of the workmen in the building and said, "Don't tell him, ask him."

In the field he was an excellent trapper and often got a larger catch with twenty-five traps than others who set out one hundred. This was because he never set a trap unless he was sure it was in a used runway or near food that would attract rodents. Although an enthusiastic collector he was still soft-hearted toward some of the mammals he had to collect. On my first trip with him to Chile, we had a young live pudu that sickened and had to be put out of the way. He wanted the animal, but hated to kill it. The collector of course won, but he said bitterly as he was sharpening the knife, "In this game, Sanborn, you could kill your own brother if you needed him for a specimen."

Those working under Dr. Osgood's direction were supervised, but never realized until later the unobtrusive direction they had had from him. I shall always be indebted to him for the years of patient help and guidance he gave me.

His friends were not all in the museum field. He had the friendship and respect of men of equal caliber of the University of Chicago with whom he lived at the Quadrangle Club. At the Memorial Service held for Dr. Osgood at Bond Chapel, University of Chicago, Professor Frank H. O'Hara of the English Department said, "... We remember the individual who enriched us by being with us. By being a part of the university community for over thirty years. By listening, and talking, and living tolerantly—and at the same time affirmatively. By being his own big-statured self. Someone once said that the greatest truths are the simplest, and so are the greatest men. We lived with one of these simple great. And knew that he was great. And that he had no need of the tag of titles. And I suppose that most of you who are here today have for a long while called him simply "Oz"—And will always think of him as "Oz"—With respect—With affection—And with great good cheer."

At the same Service, Mr. Tappan Gregory, an old Chicago friend of Dr. Osgood's and known to mammalogists for his excellent flash-light photos, said of him, "... His interests were comprehensive and keen, and he was ever alert for opportunity to serve. For one of his fine intellect and positive opinion, he had extremely broad-minded perspective and was sensitive to the views of others, always ready to modify his own judgments when persuaded of error. On any matter of public concern or private interest, his arguments were constructive, his approach fair, his conclusions just. He commanded universal respect and admiration for what he did, affection for what he was—generous in his appraisal of others, modest for himself, companionable, of a lively sense of humor and unfailing dignity and grace, courageous, and patient beyond belief. We shall miss him, but let us not mourn too grievously that he has preceded us by a few sure steps along the inevitable trail. Let us rather rejoice in the happiness he brought us and keep fresh the memories of glad days together.

'E'en as he trod that day to God
So walked he from his birth
In simpleness and gentleness
And honor and clean mirth.' "

After a short illness, while in Billings Memorial Hospital for a general check-up and rest, the end came suddenly at 3:00 P. M. on June 20, 1947. We use the term "the end" in regard to the physical, but for a man like Wilfred Hudson Osgood, there can never be an end.

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THE FRANKLIN GROUND SQUIRREL, *CITELLUS FRANKLINII* (SABINE), AND ITS RELATIONSHIP TO NESTING DUCKS

By Lyle K. Sowls

In 1938, the Delta Duck Hatchery at Delta, Manitoba, was converted to a waterfowl research station under the sponsorship of the American Wildlife Institute (now the Wildlife Management Institute). Franklin ground squirrels (*Citellus franklinii*) were then extremely numerous along the marsh edges and the wooded ridge that bordered the southern shore of Lake Manitoba. There was evidence that it might be an important predator upon the nests and young of waterfowl which nested in the dry grassy marsh edges. Hence, a study of its relationship to nesting ducks was undertaken.

As a predator upon game bird eggs, this rodent already had some black marks against it. Bennett (1938a), in his Iowa studies, and Breckenridge (in Roberts, 1932), in Minnesota, obtained records of Franklin ground squirrels destroying duck nests. Errington and Hamerstrom (1937) found it and the thirteen-lined ground squirrel (*Citellus tridecemlineatus*) to be destructive to pheasant nests in Iowa.

Similar destruction of game bird nests by other ground squirrels had been reported by several workers in the western states. Horn (1938) indicated that the California or Beechey ground squirrel (*Citellus beecheyi beecheyi*) and the Douglas ground squirrel (*Citellus beecheyi douglasii*) were serious predators upon the nests of the California valley quail. Since then, Emlen and Glading (1938) recorded an actual instance where the California ground squirrel robbed the nest of a valley quail. Stanton (1944), by a study of dummy nests in Oregon, added the pheasant and bob white quail to the list of game birds whose nests may be preyed upon by the Douglas ground squirrel.

From a survey of the literature in 1938 it was apparent that the Franklin ground squirrel was among those American mammals of which little was known. This fact has been more recently pointed out by Hamilton (1939). To fill some of the gaps in our knowledge of this rodent, a life history study was undertaken in conjunction with an investigation of its destructiveness to the nests and young of waterfowl.

Observations concerning the relationship of the Franklin ground squirrel to duck nesting were begun in 1938 by H. Albert Hochbaum. In 1939, I began a life history study of the Franklin ground squirrel and, with the help of Hochbaum, Peter Ward, Edward Ward, Torrence Ward, and Russell Ward, continued and expanded the study in relation to ducks. In 1940, the studies were continued with assistance from Ralph Morrill. In 1941, I joined the United States Navy and interrupted my ground squirrel investigations until 1946 when I again returned to Delta. In 1941, William H. Elder assisted by Torrence Ward collected data on breeding, litter sizes, and populations. From 1941 to 1946, Hochbaum observed the trend of ground squirrel populations while continuing his waterfowl investigations. Most of the findings herein presented were gathered during the years 1939 and 1940. This project was carried out under the

direction of Professor Aldo Leopold of the Wildlife Management department of the University of Wisconsin.

Further acknowledgment of able assistance is due J. Dewey Soper, who furnished me with his unpublished accounts of this mammal in western Canada and helped in preparing the manuscript. E. T. S. Norris-Elye made editorial suggestions.

The study area lies at the southern end of Lake Manitoba. A narrow, wooded sand ridge, skirting the shoreline, separates marsh and lake (Fig. 2). It is a marsh of large open bays, fed by several channels which break through the sand ridge, and of smaller isolated sloughs and potholes between bays and lake, fed by surface runoff alone. The bays and sloughs are bordered by bulrush (largely *Scirpus acutus*) and cattail (*Typha latifolia*). The whole system of tule-bordered waters is set in a matrix of phragmites (*Phragmites communis*). These phragmites fields, broken by occasional meadows, hayfields, and pastures, reach back from the marsh waters to the ridge on the north and to the prairie wheat fields on the south. (For a complete description of the Delta area, see Hochbaum, 1944.)

THE ANIMAL

In the Delta region, the Franklin ground squirrel (*Citellus franklinii*) is called the "gray gopher" and "whistling ground squirrel." Seton (1909, 1929) also called it "scrub Citelle." These names distinguish it from its close relatives, the Richardson ground squirrel or "flickertail" (*Citellus richardsonii*) and the thirteen-lined ground squirrel (*Citellus tridecemlineatus*) locally called "striped gopher." In this paper, "ground squirrel," unless otherwise specified, refers to the Franklin ground squirrel.

Weights and measurements.—Complete descriptions of the ground squirrel are given by Howell (1938) and by Seton (1929). Average and extreme measurements of animals collected at Delta for fifty-two adult males are: total length, 388 mm. (363–430); tail, 144 mm. (120–155); hind foot, 55 mm. (51–68). For twenty-eight adult females: total length, 387 mm. (367–408); tail, 139 mm. (128–155); hind foot, 55 mm. (52–57). The males were slightly heavier than the females. Of ten adult males weighed, the average was 473 grams; of seventeen adult females weighed, the average was 426 grams.

Distribution and habitat.—The known range of the Franklin ground squirrel has been mapped with considerable accuracy by Howell (1938) and more recently described by Anderson (1946). Although both writers described its range as being in the Transition and Upper Austral Zones, J. Dewey Soper has given me several recent records of this mammal's occurrence in the Canadian Zone both inside and outside of the previously described range. These records are as follows: There are two Manitoba records as far north as The Pas. The first of these was given to Soper by Warden Harry Sanderson who saw one near the shore of Moose Lake in 1942. The second was a specimen collected by Sam Waller who, in a letter to Soper dated March 4, 1946, said, "This animal has spread into the Carrot River farming area this past five years." The specimen, collected by Waller and sent to Soper for examination, was taken at Big Eddy, Saskatchewan

River, June 1, 1941. Both Howell and Anderson recorded this mammal as occurring north of the region of Prince Albert Park, Saskatchewan, but its occurrence specifically in the Canadian Zone was first reported by Soper. His letter to me, dated February 24, 1947, says, "This species goes deep into the pure coniferous forests of the Canadian Zone along the Spruce River." Further, he says, "It also occurs in equally pure 'Canadian' in southeastern Manitoba and southwestern Ontario."

Abundance within the geographic limits of the squirrel's known range varies greatly. Soper (1946) wrote, "Over extensive areas . . . they are either scarce or absent, such as on the treeless prairies west of Turtle Mountain and on the open lowlands immediately east and west of Red River, although they inhabit the wooded valley of this stream." Seton (1929) wrote, "Since 1882 when I first observed it in Manitoba the Franklin ground squirrel has greatly increased in numbers in proportion to the other species." C. C. Furniss, however, writes me that in the rolling park country around Prince Albert, Saskatchewan, it "appears to be retreating before the advance of agriculture, as it is not as common now as it was twenty years ago. On the other hand, the Richardson is increasing rapidly."

Seton pointed out that in the Prairie Provinces of Canada the gray gopher is largely confined to the edges of woods. Soper (unpublished, 1941) considered it essentially an animal of the Transition Zone of the aspen parklands found between the treeless plains and the Canadian Zone forest. Although it occasionally resorts to the latter type of country, its eastern limit at some points lies close to the western edge of the Pre-Cambrian Shield. He writes that in southern Manitoba and to the northwest it inhabits the aspen poplar groves of the prairie, as well as the wooded lake ridges and the stream and marshland borders, but is absent from the treeless and scrubless areas.

At Delta, its habitat primarily includes the wooded lake ridge that borders the marsh and small isolated tree-covered islands set in phragmites. Occasionally, ground squirrels can be found on treeless ridges where phragmites offers the only cover. Evidence of their occurrence on these ridges in late April indicates that they have hibernated there and have not moved from the wooded ridge a mile away.

Population density and cycles.—The Franklin ground squirrel is subject to violent fluctuations in numbers. Both years of extreme abundance and extreme scarcity have been observed at Delta. In 1938, they were so abundant that, on July 2, two boys with .22 rifles were able to kill fourteen in less than an hour without moving from one spot. Such numbers have not been observed since. By 1939, they had declined considerably, but were still numerous. No pronounced change in numbers was noted between 1939 and 1942. During this latter period, an observer could see, on any favorable day, about six per mile along the ridge road. In 1943, however, they were so uncommon that not over a dozen were seen by Hochbaum all summer. Hochbaum noted a slight increase in 1944 and 1945. In 1946, the ground squirrels were still rare at Delta. For the entire season, I recorded less than two dozen animals.

To gain some idea of population density, a dawn-to-dark census by shooting was undertaken. On June 29, 1940, Aldo Leopold, Torrance Ward, and I took every individual on a measured four acres. The weather was warm, calm, and bright—ideal for squirrels to be out. The day's kill was sixteen, four squirrels per acre. On the following day, I watched the area and, as I saw no squirrels, the census was apparently complete. On July 14, 1941, Dr. William H. Elder and Torrance Ward killed twenty-two squirrels (5.2 per acre) on the same area. Since the Delta ridge had been heavily shot in 1940, prior to the first census, the 1941 increase may not be significant. It should also be noted that the 1941 census was made two weeks later in the season.

By compiling the recollections of farmers and naturalists in southern Manitoba, McLeod (1933) gave the peak years of abundance as 1912, 1917, 1923, 1927, and 1932. Our Delta observations indicate that 1938 should be regarded as a peak year and 1943 as a low. By combining our Delta observations with McLeod's data for southern Manitoba, it seems likely that peaks in ground squirrel numbers can be expected every four to six years.

Life history notes.—The voice of the ground squirrel was first described by Kennicott (1857) as "a remarkably clear whistle, more musical than the voice of any mammal I have ever listened to, and as clear as that of any bird." Seton gave almost the same description, but doubted that females utter any calls. I have found that females, although not in voice so often as the males, call just as clearly.

These squirrels are good climbers. Although they lack the tree squirrels' ability to jump from bough to bough, they traverse the limbs with ease and speed. On several occasions, I have seen a male pursuing a female among the top branches of a tree. Captive Franklin ground squirrels were able to climb one-inch wire mesh walls with ease, even clinging to the wire top, whereas *richardsonii* individuals climbed the walls with some difficulty and were quite unable to cling to the top wires.

Lyon (1932) wrote, "These ground squirrels are good swimmers. I tried to drown one taken in a number 1 steel trap and found that the animal not only was able to keep afloat despite the weight of the trap, but was able to swim with it." I put a captive into a ditch to see how well it could swim; it crossed an expanse of water twenty feet wide without difficulty. Despite their observed ability to swim, I do not believe that they voluntarily cross water in their travels; dry islands, at Delta, separated from the mainland by only a few yards of open water are not inhabited by squirrels.

During the mating season, there is general fighting among the males. They bite each other around the rump, seemingly in an effort to reach the testes. At this time, nearly every male has a bare spot or a cut on its back about two inches ahead of the tail base. I saw my captive males lacerate each other several times during the season. Such injuries often become infected. When several captive males were put in a pen together, during the mating season, the strongest squirrel soon established his dominance. After dominance was established, fighting was less severe.

Seton (1929) wrote that a captive ground squirrel kept by him drank copiously

and he believed that the water supply may limit their distribution. Our captives drank water often, but did not require it when given plenty of green, succulent leaves such as sow thistle. One adult male on a diet of dry grain and no water lost weight rapidly. On the other hand, my captive Richardson ground squirrels thrived without water on a diet of grain alone. I conclude that the Franklin ground squirrel requires water, but that, in the wild, succulent plants may suffice as a supply.

My captive ground squirrels had regular places in the corners of the nesting boxes to deposit their scats and were never observed to drop them elsewhere. In several burrows that I examined, the scats were deposited in small chambers tributary to the main burrows.

The curiosity of the ground squirrel makes it easy to capture by snaring. When one is chased into its hole it does not remain down long, usually less than a minute, before curiously protruding its head to look around. At this moment, a quick jerk of the snare captures the squirrel. Many times, however, I have placed a snare where the squirrel entered only to find him watching me from another entrance to the same burrow.

According to Kennicott (1857), "It is usually found living alone or in pairs . . . this is perhaps owing to their small numbers; for the species appears to be naturally gregarious, and at times, large companies live together, burrowing within a few feet of each other, several pairs even entering the same hole." Apparently the species hibernates in groups. On the first few days after the spring emergence at Delta, many squirrels may be seen near a few dens. The Franklin ground squirrel comes out of hibernation about two weeks later than *richardsonii*. The first spring records of the Franklin ground squirrel above ground, at Delta, for the nine years 1939–1947 inclusive, are, respectively, April 18, 20, 16, 14, 21, 22, 19, 21, and 26. For the Richardson ground squirrel, they are: April 7, 5, March 29, April 1, no record, no record, March 22, 20, and April 1, respectively.

The first to emerge are the males; the females follow about a week later. The first squirrels shyly sneaking through the underbrush are not easily seen, but one hears, against the prevailing quiet, a low rustling of leaves and the cracking of hard cherry stones. Other items of food during the first few weeks following emergence are succulent roots, new shoots, leaves of stinging nettle, and grasses. Again, in late summer or early autumn when mild weather still prevails and food is abundant, the Franklin ground squirrel goes below ground for extended periods. This occurs before the catbirds have departed from the thickets and while there are still bands of downy ducklings in the marsh. A sharp decline in numbers is noted in late August or early September. By the middle of September, only a few are seen. From our own observations at Delta, we have records of these squirrels being above ground as late as October 2. J. Dewey Soper saw one in the wooded ridge, October 7, 1945. I suspect that the adults are the first to hibernate; I have found only the young of the year active in September.

The flickertail remains out much later than the Franklin ground squirrel. Many flickertails are still active in early October on the Portage plains and during mild autumns a few are seen as late as the first week in November.

In terms of active hours per year, the Franklin ground squirrel is perhaps one of the least active of Manitoba mammals. Both his day and season are short. In the vicinity of Delta, his total time above ground amounts to less than 10 per cent of his lifetime. The other 90 per cent of his life is spent in his burrow, most of it in hibernation. This paucity of active periods greatly curtails the role of the ground squirrel both as a prey species and as a predator upon other forms and it conditions his relationship with the whole plant and animal environment. During hibernation, he is available as prey only to strong diggers and to predators like the weasel which are small enough to follow his tunnels.

During the summer, his time below ground is controlled primarily by weather and light. This pattern of daily behavior, influenced by the elements, seems to be identical with that of the Columbian ground squirrel (*Citellus columbianus columbianus*). Shaw (1945) stated that "The Columbian ground squirrel is definitely diurnal and sun-loving . . . its activities largely controlled by seasonal and daily conditions of the sun, wind, temperature and climatic conditions generally." The Franklin ground squirrel is strictly diurnal and is seldom seen after sundown, usually retiring a few hours before.

On some days, even in midsummer, he does not come out at all; low temperature, rain, or wind suffice to keep him underground. Wade (1930) pointed out that soil temperature does not control the spring emergence of captive ground squirrels. It has, however, great influence on their daily activity. My captives stayed in their den boxes nearly all day during cool, cloudy weather. On rainy days, wild squirrels are seldom seen out of their burrows, but on sunny days following a sudden shower, they come out in greater abundance than at any other time. A strong wind is particularly annoying to them; on very windy days, although the weather may be clear and warm, the squirrels remain out for but a short while.

At the time of emergence in the spring, the male's testes are enlarged and descended. The scrotum is so large that it drags upon the ground, causing the hair to wear off on the lower surface. Apparently they are ready to breed. The first implantation sites in the uteri of females were observed on May 3. This indicates that the earliest copulations took place during the last week in April when the first females emerged from hibernation. Hence, the females' time of emergence seems to determine the date of breeding.

During the period of breeding, which reaches its peak during the first week in May, both sexes emit a powerful, musky scent. This musk arises from three anal glands, about 9 millimeters in diameter, embedded in the flesh around the rectum. When the squirrel is excited, the ends of the ducts show as three white spots, one above and one on each side of the anus.

For the first three weeks after their emergence the females are pursued by many males. The pursuits take place on the ground among the bushes, under the ground in the dens, and even among the tree tops. On several occasions I have watched these mating pursuits until the squirrels went into their burrows; much noise came from the burrow as they struggled underground. Since none of us at Delta have seen them copulate in the wild, it seems likely that this act takes place in the den. Copulation was observed twice among our captives. In each in-

stance the male chased the female into the nesting box, seized the back of her neck with his teeth, threw her on her side, and with all four feet held her in the same position which he employs while breaking a duck egg (see Plate I). On one occasion copulation lasted five minutes; the other time it lasted nine minutes.

The breeding season is over by the first of June and no second litter is raised. Of twenty animals collected on July 14, 1941, regression of the reproductive systems was apparent in all cases. All males collected on or after this date had testes weighing less than one gram each. In all adult females, placental sites showed clearly in the uteri, but no large follicles were present in the ovaries.

This extremely short breeding season and one litter a year seems to hold for several species of the genus *Citellus*. Wade (1927), working with the thirteen-lined ground squirrel, found that males were sexually active for only a short time in spring and that regression of the reproductive system was rapid. Shaw (1925) found the same to be true of the Columbian ground squirrel. At Delta, Elder

TABLE 1.—*Litter size in the Franklin ground squirrel*

OBSERVER	PLACE	NUMBER IN LITTER
Bailey, Bernard (1929)	Minnesota	10
Seton, E. T. (1929)	Manitoba	4
Seton, E. T. (1929)	New York Zoo	6
Parker, G. S. (Cory, 1912)	Illinois	5, 7
Sowls, Lyle K.	Manitoba	6, 7, 8, 8, 9
Elder, W. H.	Manitoba	5, 7, 7, 8, 8, 8, 8, 8, 9, 9, 9, 9, 10, 10, 10, 11

(unpublished) found that there was no possibility of a second litter in the Richardson ground squirrel due to the early regression of the reproductive system.

To determine litter size, Elder made embryo counts in animals collected in May and placental scar counts in animals collected in July. I made embryo counts to determine litter size in all but one case. The assembled data on twenty-six litters (Table 1) shows a range in size from five to eleven with an average of 7.5 young.

A pregnant female, captured on May 15, 1940, gave birth to eight young on June 2. At birth the young are about an inch long, naked, and reddish pink in color. No weight was taken for four days for fear that disturbance would cause the mother to devour them. On the second day one disappeared and it seemed likely that she had eaten it. The development of the remaining young is shown on Plate II. I weighed the young squirrels every three days and thus obtained the growth curve presented in Figure 1. This curve is terminated after five weeks because at that age the young left their mother and escaped.

From a condition of naked helplessness, the young developed rapidly. By the ninth day they were covered with short hairs; by the sixteenth day they were fully haired. On the eighteenth day their eyes began to open, and by the twentieth day the eyes were fully opened. From then on the young were no longer content to lie in the nest, but began exploring the brood chamber and giving

voice to shrill whistles. At thirty days they undertook short excursions out of the brood chamber and were whistling constantly.

The young squirrels escaped on July 13, at thirty-nine days of age. Thereafter, I had to rely on specimens of wild young to study development. I was unable to secure enough weights to extend Figure 1, but by the middle of September the wild young, presumably about seventeen weeks old, were almost as large as their parents.

Wild young are apparently weaned early in July. Many young, all of one size, come out along the ridge road at that time. This fact sustains the ana-

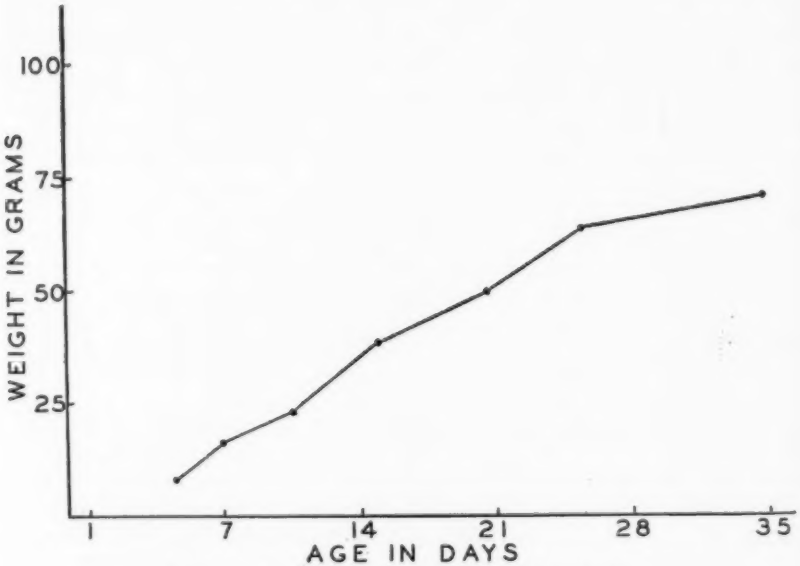

FIG. 1.—Growth curve of Franklin ground squirrels.

tomical evidence of a limited breeding season. In 1939, the first young squirrels appeared on July 2 and in 1940, on July 5.

In preparation for the birth of her young, the female carries much grass into her burrow. On June 20, 1940, I watched a wild female, apparently with young or preparing to have young, carrying grass into her den. She made a dozen trips in an hour, each time carrying a large mouthful of quack grass (*Agropyron repens*). Although many other plants were present the quack grass seemed to be preferred.

The Franklin ground squirrel has been regarded by most writers as an omnivorous feeder. To determine the foods and feeding habits of this rodent at Delta, I used three methods of study: stomach analysis, field observations, and artificial feeding of captives. By these means, I tried to determine palatability of wild foods, the amount of food consumed, the methods of killing prey, and

PLATE I

Franklin ground squirrel breaking a duck egg. Photo by M. D. Pirnie

general feeding habits. No single method of study proved adequate, but the gaps left by one were usually filled by another.

Table 2 shows the principal foods found in the 178 stomachs examined. Much of the vegetation was so finely chewed that it could not be identified, and is

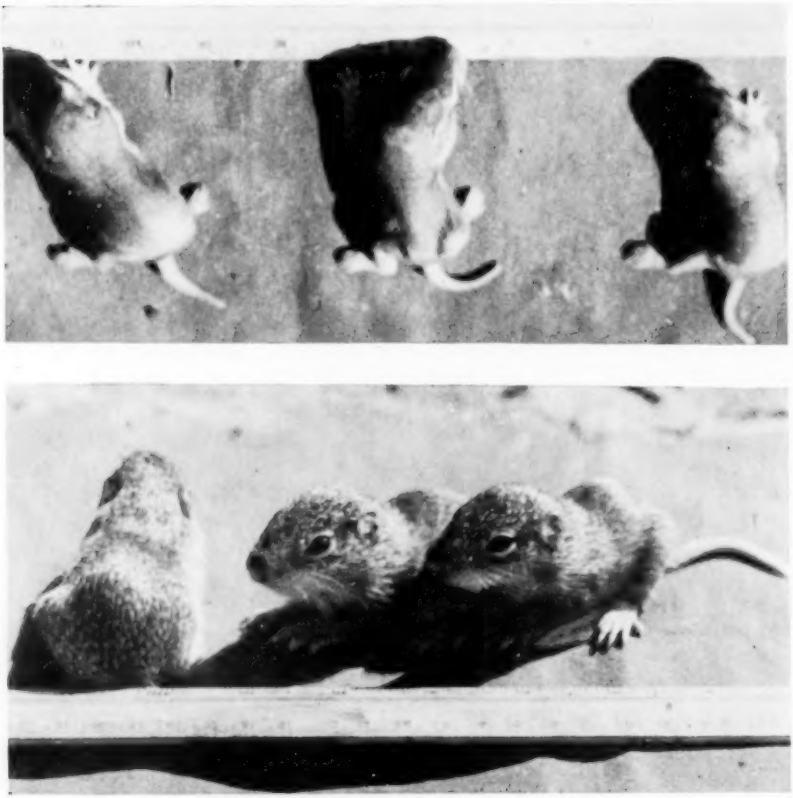

PLATE II

Upper: Franklin ground squirrels ten days old
Lower: Franklin ground squirrels twenty-four days old

listed as unidentified herbage or roots. Vegetable material made up over three-fourths of the total bulk of stomach contents. Small diagnostic parts made it possible to identify most of the animal matter.

In April, when ground squirrels come out of hibernation at Delta, their principal foods are succulent roots, cherry stones, green nettle shoots, and grasses. By about May 10, the tender shoots of wild pea, sow thistle, dandelion, wild

cucumber, and many other plants augment the diet. From then on the vegetation develops rapidly. By June 15, the beach pea is in bloom and by the last of June its seeds and pods furnish a large part of the ground squirrel's food. From July 1 until autumn is a time of plenty. The sow thistle, a favorite food, furnishes leaves, buds, and blossoms which are eaten in large quantities. The red-

TABLE 2.—*Frequency of occurrence of principal foods of the Franklin ground squirrels in 178 stomachs collected in 1938, 1939, and 1940*

FOODS	NUMBER OF STOMACHS CONTAINING EACH FOOD					
	April	May	June	July	August	September
VEGETABLE MATTER						
Sow thistle (leaves, buds, blossoms)				7	6	2
Beach pea (seeds and pods)			4	10	2	
Chokecherry (fruit and stones)	5				11	1
Red-berried elder (berries)				9	1	
White clover (leaves)					1	
Unidentified seeds		1		11	2	
Unidentified herbage			22	51	5	
Unidentified roots and tubers	7	5				
ANIMAL MATTER						
Mice (adults)			5	8	1	
Mice (young)				4		
Snowshoe hare			2	2	1	
Toads				5		
Carrion		2		3	3	
INSECTS						
Ants				1		
Beetle		1	2			
Grasshopper eggs					2	
Grasshopper					4	
Unidentified larva				4		
Unidentified pupae			9	1	2	
BIRD REMAINS						
Unidentified passerine			2			
EMPTY			1			
TOTAL STOMACHS EXAMINED	12	9	39	84	31	3

berried elder fruits ripen about July 10 and the chokecherries begin to ripen the first week in August. Although climbing is required to obtain these two bushy fruits, they make up a large proportion of the food. After August they shrivel and fall to the ground, thus becoming more available. The stinging nettle, which is extensively eaten in the spring but grows beyond reach in July, becomes

top-heavy and loaded with seeds in August. After the stems bend toward the ground the squirrels eat the seeds and terminal buds.

Instances of garden depredations by the "gray gopher" have been described by several writers and can be heard from almost every farm gardener on the Portage plains. There, the farmstead and garden are usually located in the shelter of a prairie bluff which is the habitat of many ground squirrels. In the wild, and among my captives, I found that the squirrels were very fond of carrots, garden peas, string beans, tomatoes, and potatoes. They would not eat rhubarb, onions, or peppers.

The carnivorous tendencies of the Franklin ground squirrel have been discussed by Vernon Bailey (1893 and 1926), Johnson (1922), Seton (1929), and Howell (1938). According to Bailey, animal matter makes up about one-third of its food. In summing up the meat eating propensities of the gray gopher, Howell said, "Individuals of this species have been known to kill and eat wild mice and a young rabbit, to rob a meadowlark's nest, to kill a wood pewee, to capture small chickens, and to eat hens' eggs." Stomach analysis data and field observations at Delta likewise revealed a strong carnivorous tendency; about one third of the 178 stomachs contained animal matter. No quantitative analysis was made.

Live mice, placed in pens with captive squirrels, were always eaten, but dead, cold mice were refused. The squirrel invariably seized the mouse by the head and began eating it while still kicking. With the mouse in its forepaws, it carefully pealed back the skin and large intestine. Such remnants of mice, including parts of the viscera and tail, were often found along the ridge road, with tracks in the sand as evidence that a mouse had been killed and eaten by a ground squirrel. Of the 178 stomachs, 14 contained remains of adult mice and four contained young mice remains. The latter were presumably obtained by robbing a nest. Mice are abundant on the Delta ridge and, from evidence at hand, constitute an important part of the ground squirrels' animal food in this locality.

In 1939, I saw ground squirrels eating toads and frogs along the ridge road. In 1940, live toads and frogs were offered to the captive squirrels. Upon sighting a toad, the squirrel seized it and began pawing the toad's back with its sharp claws. This was probably to dispose of the external serous glands which apparently impart a bad taste. After early sampling bites, the squirrel wiped its mouth on the ground. If the first bites were distasteful, pawing and tasting were continued until the toad was rendered palatable. Then the head was eaten, finally the entire toad was consumed.

It is a common sight to see one of these rodents dash from the edge of the "bush" into the roadway and seize a grasshopper. It then retreats to the edge of the roadside vegetation and, holding the grasshopper in its forepaws, quickly devours it. The squirrel when thus seeking cover usually selects the shady edge of the road rather than the sunny side.

Nearly everyone who has written about the Franklin ground squirrel has mentioned it as an enemy of poultry. This charge was attested by several farmers on the Portage plains whom I questioned. Mr. Stuart Criddle of Treesbank,

Manitoba, wrote me that "They often become a serious pest to poultry as they destroy large numbers in quick order. I have known them to kill fowl nearly half grown." Evidence of depredations upon ducklings will be discussed later.

Vernon Bailey (1926) wrote, ". . . when caught in traps or found dead, they are even eaten by their own kind." At Delta, cannibalism was observed twice among captive animals and once in the wild. On July 8, 1940, one young squirrel escaped from its pen into the neighboring enclosure where an old female was kept. When I visited the pen she had eaten all of the young squirrel except the inverted skin, large bones, tail, and parts of the viscera. The other instance occurred on August 2, 1940, when an old male devoured another adult squirrel which had been kept in the same pen and had killed itself on the wire trying to escape. On July 18, 1938, Albert Hochbaum found an old squirrel devouring a freshly killed young one.

The Franklin ground squirrel as a prey species.—Available information indicates that the Franklin ground squirrel, when compared with other rodents, is relatively unimportant as food for carnivores or birds of prey. This is probably because the squirrels spend so short a part of their lives above ground, because they are hard to catch, and because they are less abundant than the smaller rodents. The existing information on this matter is from scattered localities with diverse ground squirrel densities, and it is therefore difficult to interpret.

According to Seton (1929), the Franklin ground squirrels' principal enemy in Manitoba is the red-tailed hawk (*Buteo borealis*). This seems likely in the case of animals living in the prairie "bush," but on the Delta ridge the red-tail is uncommon. Errington and Breckenridge (1938), working in Minnesota, Iowa, and North Dakota, found Franklin ground squirrel remains in only two of forty-four red-tail stomachs examined. In the Delta area, the marsh hawk (*Circus*) is the most abundant nesting hawk, but it lives principally upon mice and fledgling blackbirds. Of sixty-six marsh hawk pellets examined by us, only two contained ground squirrel remains. Working in the same region where they gathered red-tail data, Errington and Breckenridge (1936) found young Franklin ground squirrel remains twenty-two times and adult remains three times in 336 marsh hawk pellets.

Other resident hawks at Delta include the Cooper's hawk (*Accipiter cooperi*) and the broad-winged hawk (*Buteo platypterus*), both of which nest in small numbers on the ridge. We found no evidence that they preyed heavily upon the ground squirrel, but some predation by these hawks seems likely, especially during the late summer flight when migrants from the north augment their numbers. In addition to these, the rough-legged hawk (*Buteo*) and the sharp-shinned hawk (*Accipiter velox*) are common during migration. I obtained no stomachs or pellets from these hawks. Errington and Breckenridge, however, found ground squirrel remains in one out of twenty-three rough-legged hawk stomachs examined from Iowa, Minnesota, and North Dakota.

At Delta, the nocturnal raptors are the great horned owl (*Bubo*), which nests on the ridge, and the short-eared owl (*Asio flammeus*), which nests in the marsh. I studied the pellets and food remnants around two horned owl nests, but found

no evidence of horned owl predation upon this squirrel. In Iowa, Errington, Hamerstrom, and Hamerstrom (1940) found remains of *Citellus* (undetermined species, either Franklin or thirteen-lined) only eight times in 4,815 pellets, or in 0.2 per cent of the pellets they examined. No long-eared owl (*Asio wilsonianus*) pellets were examined by me. Of 100 short-eared owl pellets, which I examined, none contained remains of the ground squirrel. From the data at hand it seems that raptorial birds do not cause heavy mortality among the ground squirrels at Delta.

Seton (1929) lists the weasels, mink, fox, and coyote as important enemies of the Franklin ground squirrel in southern Manitoba. The skunk (*Mephitis*) which is generally common in all ground squirrel habitat should be added to this list. The short-tailed weasel (*Mustela erminea*) and the long-tailed weasel (*Mustela frenata*) are abundant. In the fall of 1939, Mr. Edward Ward observed a long-tailed weasel killing a ground squirrel. The weasel had taken the squirrel from its hibernating burrow as evidenced by tracks in the snow. I examined 122 mink (*Mustela vison*) scats and found ground squirrel remains in only three. However, most of these scats were collected in the deep marsh and the scarcity of squirrel remains is therefore not a fair index to mink predation.

Errington (1937), in Iowa, found Franklin ground squirrel remains in one of eleven badger (*Taxidea*) scats, and in one of fifteen red fox (*Vulpes fulva*) scats (1935) which he examined. Foxes and coyotes (*Canis latrans*) were rare at Delta during the period 1938 through 1942. In 1943, foxes became common and the number of coyotes increased. We have never seen badgers on the Delta ridge, but they are occasionally seen on the prairies bordering the marsh on the south.

From data available, I believe that predation upon the Franklin ground squirrel is light and does not serve to check its increase. The cause of declines in ground squirrel populations, such as occurred at Delta between 1938 and 1939, are as yet obscure. McLeod (1933) believed that climatic extremes, infertility, and bacterial and helminth parasitism may account for die-offs.

Parasites and disease.—A parasitological survey of the genus *Citellus* in Manitoba has been made by McLeod. Hence, I made no special effort to study the parasites of the Franklin ground squirrel. Stomach worms, however, were noticed while examining stomachs for food contents. Their identity was determined by Dr. B. B. Morgan, Department of Zoology, University of Wisconsin, to be: *Citelliiema bifurcatum* (in six of forty-five stomachs), *Sublura* sp. (in two), and *Physaloptera massino* (in two). All of these parasites except one (*Sublura*) were previously found by McLeod. In addition to these, McLeod found two internal parasites (*Rictularia citelli* and *Weinlandia citelli*).

Most of the ground squirrels collected at Delta were infected with external fleas of the genus *Orchopeas*. As soon as the animal is killed these fleas leave the body; hence, no accurate count on the fleas per squirrel could be made because most of them were shot by local boys and I did not see them until several hours later.

In addition to the adult forms of parasites found, one female ground squirrel, collected in July, 1940, had a tapeworm cyst (*Cysticercus* sp.) in the liver. One

squirrel had large amounts of calcium deposited throughout the mesentery and liver. The cause of this general calcification was not known.

RELATIONSHIP TO DUCKS

The ground squirrel as a predator in the Delta Marsh.—In late June, 1939, Hochbaum followed the histories of ten ducks nests; in 1939 we studied seventy-eight nests, and in 1940, one hundred eighteen. Thus, over the three-year period, the histories of 206 nests were completed. We used the procedures outlined by Errington and Hamerstrom (1937) and by Kalmbach (1937) to find the extent of nest destruction by predators. These included the cruising of nesting cover and the revisiting of nests to determine their outcomes. Most nests were found by flushing the hen from the nest in the morning. In searching for nests, and in revisiting them, we heeded Kalmbach's precautions. Vegetation about the nest was not disturbed, extreme care was taken to avoid the creation of trails through the nesting cover, and nest hunting ceased when crows or ground squirrels were noted in the vicinity.

Decisions regarding the outcome of nests were made after a careful study of all available evidence, particularly remaining egg shells. Hatched nests were identified by the characteristic clean-cut shell and egg-cap membranes. Predator destruction (crow, ground squirrel, and skunk) was identified by the evidence left by the predator in breaking the eggs. The eggshell evidence was compared with samples of destructive work done by the three predators. For crow (*Corvus*) and ground squirrel work we fed eggs to captives to obtain samples. To determine appearance of skunk damage, we placed eggs at their dens and later studied the destruction. Each predator leaves evidence that is characteristic of his work.

The skunk and the ground squirrel broke the shell with their teeth, employing paws and tongue as well to enlarge the opening. The crow broke the shell with its bill. Plate III shows egg shell remains from each predator's destruction. Characteristic evidence of the work of each is here summarized:

The crow and the ground squirrel usually break only half or less than half the shell; the skunk usually breaks more than half the shell.

Crows never crush the shell; ground squirrels seldom crush the shell; skunks usually crush the shell.

Ground squirrels and crows do a clean job of eating the egg contents, seldom leaving a "mess" on shell or in the nest. Skunks spill much of the egg contents on the shell or in the nest.

Ground squirrels, biting at the shell, leave small chips of egg shell and sometimes tooth marks. Skunks less frequently leave chips or tooth marks, but, when present, they are larger than those of the squirrel. The crow frequently, but not always, makes a small sharp perforation with the lower mandible to one side of the main opening. There may be several such bill marks.

Although crow and ground squirrel damage may appear at first glance to be the same, the opening made by the crow is usually smaller than that of the ground squirrel and more frequently is near one end of the egg. In ground squirrel damage, small fragments of shell clinging to the membrane at the margin of the opening are curled inward. The opening made by the crow is clean-cut, broken shell and membrane seldom curl inward.

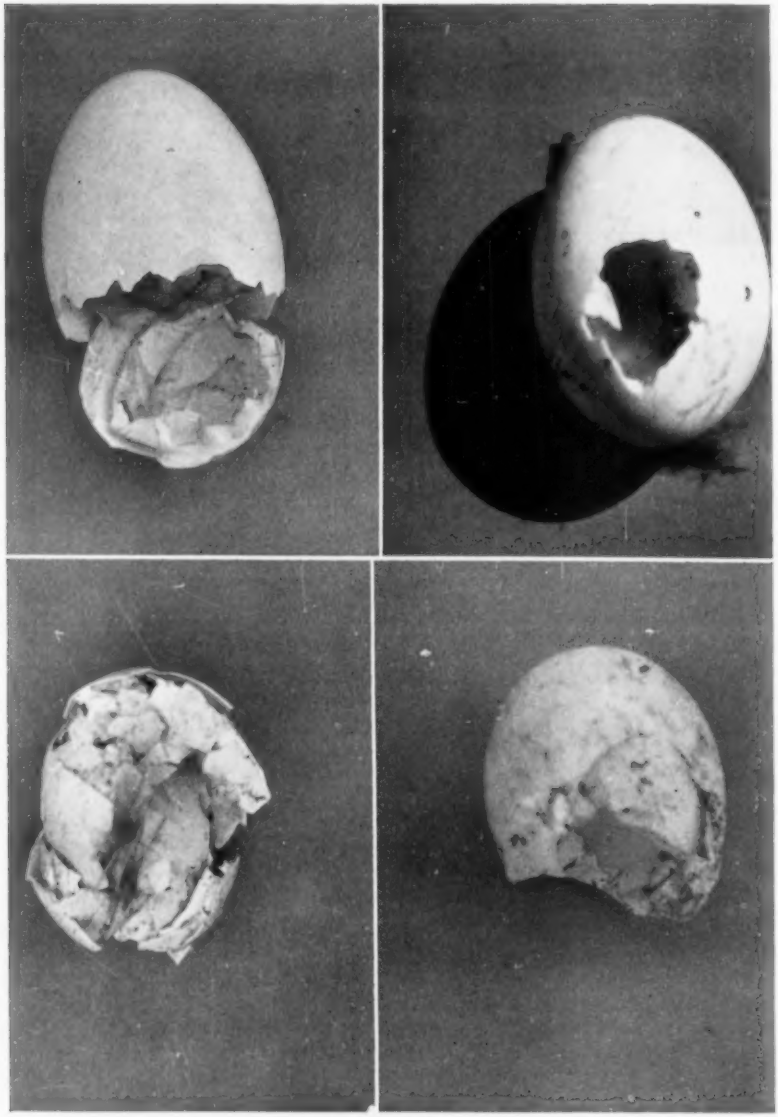

PLATE III

Egg shell remains from: upper left, hatched nest; upper right, nest destroyed by crow; lower left, nest destroyed by skunk; lower right, nest destroyed by ground squirrel. Photo by W. H. Carrick.

The crow and ground squirrel sometimes carry the eggs away from the nest and leave little evidence. In most instances, where the eggs have been transported, one may expect to find the remains of one or more eggs within a few feet of the nest. I have never known the skunk to carry eggs away from the nest.

The ground squirrel's method of breaking eggs.—Several times we have seen ground squirrels carrying egg shells, but we have never seen a squirrel find and rob a duck nest. I used my captive animals to observe the manner of breaking eggs. With its nose, the squirrel moves the egg to a depression or against a mound of earth or clump of grass where it cannot roll away. He then places his front legs over the egg, pulls it under his body and locks it there by bringing his hind legs forward (Pl. I). He presses his teeth and front legs backward against the egg and his hind legs forward in several hard simultaneous thrusts. In this manner our captive squirrels were able to break eggs of all species of ducks common to Delta except those of the canvasback. The canvasback egg, apparently, is too large and thick-shelled to be easily broken. The initial thrusts enable the teeth to perforate the egg shell, but this perforation is soon enlarged by biting off pieces of the shell. Some small pieces of shell are devoured, but most of them are discarded. I tested many captive squirrels, but found no individual differences in eagerness or method of breaking and eating duck eggs.

Errington (1938) found that some but not all of his captive thirteen-lined ground squirrels were able to break quail eggs, and that they soon gave up if they were not at first successful. These squirrels did not use their bodies as did my Franklin ground squirrels, but used only their mouths. Emlen and Glading (1938) have shown that the California ground squirrel (*Citellus beecheyi*) breaks quail eggs with its mouth only.

A series of movies and still pictures of a captive Franklin ground squirrel robbing a dummy nest were taken at the Delta station in 1940 by a Ducks Unlimited (Canada) photographer. These have been widely distributed in recent years captioned as a wild squirrel robbing a real duck nest. Table 3 is a summary of the outcomes of 206 duck nests. The nests are divided into three groups: hatched, destroyed, and deserted. The second group is further divided to show the cause of destruction.

Thirty-five per cent of the 206 nests hatched successfully. This is a much lower degree of success than was recorded by other workers at other places. Of 512 nests of thirteen species in Alberta and Saskatchewan, Kalmbach (1937) found 49 per cent hatching successfully. In North Dakota he (1938) found 54.4 per cent of 351 nests successful in 1936 and 69.3 per cent of 566 in 1937. Of 223 blue-winged teal nests, Bennett (1938a) observed a successful hatch of 59.6 per cent in Iowa. Low (1945) studying 160 redhead nests in Iowa, reported 56.2 per cent as hatching. Kalmbach (1939), reviewing the available data on nesting success studies, showed that, of 7600 nests of thirteen species of ducks and the Canada goose, the average hatch was 60 per cent.

In our Delta study, 96 nests (46 per cent) were destroyed by predators. Of this number, 25 (12 per cent) were taken by the Franklin ground squirrel. Obviously, nests over water or nests on islands were not vulnerable to ground

squirrels. I have no evidence of squirrels swimming to nests in emergent vegetation and the islands are not inhabited by squirrels. Figures 2 and 3 show the relationship of duck nesting areas to ground squirrel habitat.

Of the 206 nests, 126 (62 per cent) were on dry land within ground squirrel habitat. Thus, the 25 nests destroyed represent 19 per cent of vulnerable nests. Within its habitat at Delta during 1938, 1939, and 1940, then, the ground squirrel was probably as important as the crow in nest destruction. The crow destroyed 43 (21 per cent) nests. The heaviest ground squirrel losses were among the river ducks which as a group nest most frequently within squirrel habitat. Of the 117 river duck nests, 104 (88 per cent) were vulnerable. Of these nests 16 (15 per cent) were destroyed by squirrels.

TABLE 3.—*Outcome of 206 duck nests: 1938 (10 nests), 1939 (78 nests), 1940 (118 nests)*

SPECIES	TOTAL NESTS	PER CENT HATCHED	PER CENT DESTROYED BY:					
			Crow	Squirrel	Skunk	Unknown	Flood	Deserted
Mallard	36	33	11	8	14	14	6	14
Gadwall	6	16	16	50	16			
Pintail	34	23	23	9	6	6	26	6
Blue-winged teal	33	35	18	21	11	6	6	
Shoveller	8	25	12		25		12	25
Redhead	52	42	25	13	4	4	4	7
Canvasback	24	58	25					17
Lesser scaup	10	20	30	20	10			20
Ruddy duck	3	33	33					33
Total	206	35	21	12	8	6	8	10

Among the 89 diving duck nests, 22 (24 per cent) were within ground squirrel habitat. Nine of these nests (41 per cent) were destroyed by ground squirrels. The canvasback and ruddy duck rarely nest on dry land. The redhead nests

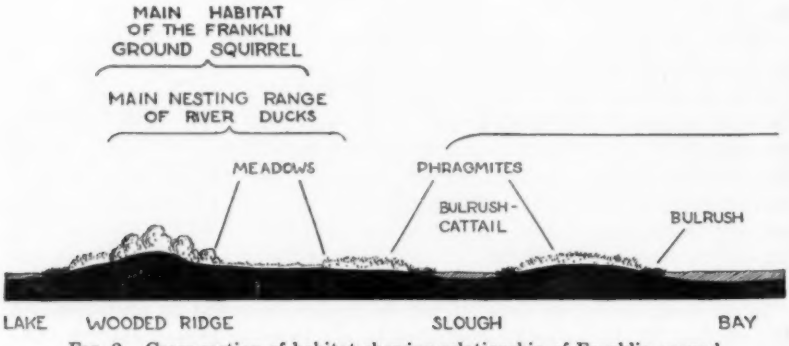

FIG. 2.—Cross section of habitat showing relationship of Franklin ground squirrel and duck nesting areas.

primarily over water and many lesser scaups do likewise; hence, although destruction was heavy among the few land nests, ground squirrel pressure on the diving ducks is not so severe as on the river ducks.

Broods of all land-nesting species must travel over land from nest to water. Likewise, broods abandoning drying sloughs and broods traveling from marsh to lake move overland. Among river ducks especially, broods frequently take to land on feeding excursions. Such broods on land are subject to predation by squirrels. Evidence of such predation is fragmentary.

One instance of a squirrel's killing an almost fully grown mallard was observed by Albert Hochbaum and Edward Ward on July 9, 1938, when they were releasing pen-reared mallards on the lakeshore. Hochbaum said, "Most of the ducks were released along the open beach, but one group was given its freedom in beach peas 40 yards from water. The moment the crates were opened a Franklin ground squirrel darted from the weeds and immediately attacked one of the mallards at our very feet. The squirrel savagely bit at the duck's back, then killed it with a bite at the base of the skull. Even before the duck had stopped kicking the squirrel was tearing at the feathers and skin of the breast, then eating the flesh. In his action the squirrel reminded us of a weasel at the kill. The job was done quickly and surely, not appearing to be the work of a novice. After the kill we drove the squirrel away and escorted the other ducklings to water. Upon returning three hours later we found only bones and feathers of the duck remaining and everywhere about these in the sand were squirrel tracks."

On July 18, 1940, I placed a three-quarter grown mallard into five successive squirrel pens. The first four squirrels paid little attention to the duck. The fifth one, a large adult male, quickly seized it, killed it, and ate it in the manner described by Hochbaum. The same day, Peter Ward and I tethered some three-quarter grown pintails in the middle of the road in squirrel infested territory. The squirrels paid little attention to the ducks.

Redhead broods are seen in overland travels more frequently than any other

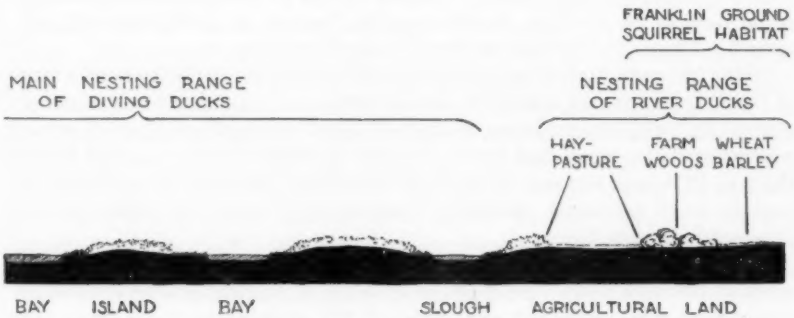

FIG. 3.—Cross section of habitat showing relationship of Franklin ground squirrel and duck nesting areas.

species and may suffer the heaviest losses from squirrels. Nevertheless, we have watched broods many times through 20 power glasses as they traveled along squirrel infested roads, but we have never seen a squirrel take a duckling from a brood. We have, however, frequently found remains of young redheads along the road with indications of ground squirrel predation. In two instances we have found ducklings at the entrance of a ground squirrel burrow. I believe it is the individual duckling straying from the brood which is taken most frequently. So long as the brood remains together the birds are apparently safe.

This concept of "safety in numbers" is based on an observation recorded by Hochbaum on July 31, 1938: "I followed a female redhead and her five half-grown ducklings for about a mile along the road, keeping as far behind as possible and watching with 24-power glasses. There were many ground squirrels feeding along the roadside, but always they scurried to the edge of the weeds as the brood passed, then returned to the road after the brood had moved on. Finally I flushed the hen, then retired to a distance to watch the brood as it continued along the road. As the young now approached a group of three squirrels the animals ran towards them. The ducklings stopped in the middle of the road, crowding together in a huddle, each lifting its head as high as the neck would stretch. The squirrels approached to within three feet of the ducklings, and for several minutes squirrels and ducklings eyed each other, motionless. Then, one by one, the squirrels ran back to feed at the roadside and the ducklings, after a few more minutes, waddled on their way, reaching the bay forty yards beyond in safety." Since most ducklings travel overland in broods, usually attended by the mother, I doubt that ground squirrel predation upon ducklings is heavy.

Significance of ground squirrel predation.—These Delta studies suggest that the Franklin ground squirrel may be an important predator upon duck nests. The range of the Franklin ground squirrel covers much of the best waterfowl breeding ground in North America; principally the Dakotas, Minnesota, Iowa, and the three prairie provinces of Canada. *Do the Delta findings apply in other parts of this vast area* and *are the years of our study representative?* Let us attempt to answer this question from the information available.

Other workers, investigating the nesting success of ducks in other places, give us a clue as to whether ground squirrel damage to duck nests is widespread. These other studies are here discussed by area.

Of the 512 nests studied by Kalmbach (1937), 334 were within the known range of the Franklin ground squirrel in Saskatchewan. Though some nests were destroyed by unknown predators, Kalmbach found no direct evidence of ground squirrel predation upon duck nests. He said of certain areas, ". . . nests located there in 1934 were exposed to attack or disturbance not only by crows but by various small mammals, including roaming dogs, and, on higher ground, by ground squirrels."

Furniss (1938), working in the same area in 1935 and 1937, completed the histories of 108 duck nests. He found no evidence of Franklin ground squirrel destruction to duck nests and only three of 108 nests, about 3 per cent, were destroyed by an unknown predator.

In July 1940, Peter Ward and I made a brief nesting survey in the Netley marsh at the south end of Lake Winnipeg. This study was done primarily to determine effects of hay mowing upon duck nesting. We did not make complete history studies, but found thirty-one nests and determined their outcome. We found no damage done by the Franklin ground squirrels although they are common in the Netley area.

Kalmbach (1938) reported on the success of 917 duck nests, predominantly river duck species, on the Lower Souris Refuge, South Dakota, in 1936 and 1937. Although some nests were destroyed by unknown predators, Kalmbach did not mention the Franklin ground squirrel as an important predator upon duck nests there. In addition to the 917 nests studied in 1936 and 1937, Kalmbach (1939) had available to him the records of 620 duck nests studied on the same area by M. C. Hammond of the U. S. Biological Survey. In reviewing all nesting success studies in this latter paper, Kalmbach did not mention the Franklin ground squirrel as a predator upon duck nests.

It should be re-emphasized that the ducks nesting on the Lower Souris Refuge are predominantly river ducks and their nests are more vulnerable to destruction by small mammals than are the nests of diving ducks.

Bennett (1938a), investigating the nesting success of the blue-winged teal in the Ruthven area in Iowa, 1932 through 1936, found the Franklin ground squirrel responsible for the destruction of 1.6 per cent of 250 nests studied. Although this percentage is small, Bennett concluded, "It is possible that increased populations of the Franklin ground squirrel could be an important factor in nest destruction." Although this study covered five years in the same region, all nest destruction by the ground squirrel occurred in 1935, a drought year in the Ruthven area.

In addition to the blue-winged teal nests, Bennett (1935) reported on 103 duck nests of other species in 1933 and 1934. Of this group he found no nests definitely destroyed by the Franklin ground squirrel although he said, ". . . Franklin ground squirrels were common over both periods." Low (1945), also working in the Ruthven area, studied 160 redhead nests in 1938, 1939, and 1940, and found no direct evidence of ground squirrel predation. He said that the Franklin ground squirrels may have access to redhead nests which are exposed by receding water levels. Low concluded that "The destructive animals so commonly associated with land-nesting duck species were largely eliminated from consideration because the water over which the redhead nested rendered the nests practically inaccessible to terrestrial predators." Bennett (1938b) reported on an additional 22 redhead nests studied over a five year period and found no damage by the Franklin ground squirrel. Bennett (1938b) and Low (1941) studied twenty-two and seventy-one ruddy nests, respectively, in Iowa and found no damage by Franklin ground squirrels. Low's conclusion on the inaccessibility of redhead nests to terrestrial predators holds true with ruddy ducks. As a rule, ruddy duck nests are even less accessible than those of the redhead.

The fact that investigators in other areas did not find the Franklin ground squirrel destructive indicates either that there was little damage by this rodent

or that ground squirrels were not abundant enough to cause damage. I conclude that ground squirrel predation upon duck nests is a local problem, causing serious losses only *during certain years* and *in certain places*. Marshy areas with *wooded* borders offer most ideal situations for ground squirrel predation upon duck nests. Such is the Delta marsh where nineteen miles of wooded ridge furnish an ideal ground squirrel habitat bordering a duck-nesting marsh. J. Dewey Soper, who has had many years experience in the waterfowl breeding grounds of western Canada, wrote me: "So far as I know, the Delta area is the largest in the prairie provinces where the Franklin ground squirrel habitat borders on such important duck-nesting ground."

Ground squirrel control.—Ground squirrel control as practiced in agricultural country is not suited to wild marsh areas. This is due to the amount of disturbance of and risks to desirable forms of wildlife that accompany such methods. Shooting as a means of control, in addition to the disturbance factor, is too costly to be practical. In a test at Delta, it required thirty man-hours to eliminate the ground squirrels on one acre of duck-breeding habitat—using shotgun and rifle. The animals are very alert when hunted, hard to kill in dense cover, and, as we have seen, spend only a relatively short time above ground.

Poisoning is a non-selective method, too dangerous to desirable wildlife species. For example, Linsdale (1931) found that in poisoning California ground squirrels at least sixty species of wildlife other than ground squirrels are known to have been killed.

The wisest policy in regard to the Franklin ground squirrel in a wild marsh seems to be to let cycles run their course and not attempt means of artificial control. When dealing with rodents subject to violent reductions in numbers from natural causes, such as the Franklin ground squirrel, artificial control may even help the continued abundance of the rodent rather than hinder it. Hamilton (1937), working on the meadow mouse (*Microtus pennsylvanicus*), said, "All available evidence indicates that disease is the control factor that terminates these mass increases of rodents . . . and . . . where great masses of mice assemble following a rapid increase in numbers, the spread of contagious disease is spectacular." McLeod (1933), working on the genus *Citellus* in Manitoba, suggested that epidemic disease regularly occurs when populations reach a certain density. Linsdale (1946) discussed another aspect of control's aiding rather than hindering rodent populations. Of the California ground squirrel Linsdale said, ". . . one effect of extensive killing of squirrels is to increase the rate of producing young by the survivors."

SUMMARY

The average weight of ten adult males was 473 grams; seventeen adult females, 426 grams.

Franklin ground squirrels range primarily in the Transition Zone, but overlap into "pure" Canadian types along the northern fringe of their range in Canada. They are animals of the "edge." Their favorite habitat is the area where woods and open country meet.

Population densities are extremely variable over a period of years and cyclic declines and rises are in evidence. A peak population was reached at Delta, Manitoba, in 1938.

A nine year average emergence date at Delta was April 19. A seven year average emergence date for the Richardson ground squirrel in the same region was March 29.

Males are the first to emerge from hibernation.

Daily activity is greatly influenced by sunlight, wind, and temperature. Less than 10 per cent of the ground squirrel's entire life is spent above ground.

Mating takes place as soon as the females emerge. Only one litter is raised per year. Average number of young from twenty-six records of fetuses and litters was 7.5.

Exact length of gestation period is unknown.

The young develop rapidly and by the autumn of the first year are nearly as large as the adults.

Animal food makes up about one-third of the ground squirrels' diet. It includes mice, young snowshoe hares, toads, frogs, insects, and occasionally young birds and birds' eggs. The principal plant foods at Delta include sow thistle, stinging nettle, beach pea, red-berried elder, chokecherries, and white clover.

Squirrel predation upon gardens is common. Vegetable preferences are peas, beans, lettuce, cabbage, newly planted corn, carrots, tomatoes, and potatoes. Captive squirrels would not eat onions, rhubarb, or peppers.

Cannibalism was noted twice among captive squirrels.

Enemies of the ground squirrel are the buteo hawks, weasels, mink, and skunks. From evidence obtained at Delta, it seems that predators are relatively unimportant in checking the numbers of this rodent.

Parasites found in Delta specimens were *Citelliiema bifurcatum*, *Sublura sp.*, and *Physaloptera massino*.

Predation upon wild duck eggs was determined by studying the outcome of 206 duck nests during 1938, 1939, and 1940. Of this figure, 126 (62 per cent) were within the habitat of the squirrel. Of 126 vulnerable nests, 25 (19 per cent) were destroyed by squirrels. Within its habitat at Delta during these three years, the Franklin ground squirrel was probably as destructive of duck nests as was the crow. The crow destroyed 43 (21 per cent) nests. The ground squirrel grasps a duck egg under its body, thrusts it forward against the teeth by using the hind legs, and thus breaks a small hole in the shell. The hole is then enlarged by biting off fragments of the egg shell.

The Franklin ground squirrel is able to kill young ducks which are almost fully grown. A brood making an overland excursion is fairly safe from squirrels so long as it remains together; however, scattered broods or strays from the brood are vulnerable to attack. Ground squirrel predation upon duck nests is a local problem *in certain places at certain times*. The Delta area, in 1938, 1939, and 1940, apparently offered ideal conditions for maximum destruction.

Ground squirrel control in wild marsh areas is too costly and too harmful to beneficial forms of wildlife to be practical. When populations are dense enough,

disease and parasites cause sharp declines in numbers. Artificial control may do more harm than good by averting these natural controls.

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THE SKULL OF THE LOUISIANA MUSKRAT (*ONDATRA ZIBETHICA RIVALICIA* BANGS): I. THE SKULL IN ADVANCED AGE

By Harley N. Gould and Florence B. Kreeger

For an introductory statement of the general purpose of this and projected studies, we cannot do better than quote a sentence written by J. A. Allen (1894): "In view of the stress naturally, and very properly, laid upon the importance of cranial characters in the discrimination of species in groups of closely allied forms, it seems desirable to ascertain the character and amount of change in not only the general form of the skull but in the form of its separate bones due to growth, and also to determine the amount and kind of individual variation that may be expected to occur in skulls unquestionably of the same species." Our original objective was a craniometric study of the adult skull of the Louisiana muskrat, made on a sufficiently large number of specimens to demonstrate the full range of variation in size and proportions, with attention to sexual and geographic variations. Such a study could serve as a standard for comparison when smaller collections of muskrat or other rodent skulls are to be assayed regarding their taxonomic positions, ecological or geographic variations, and evolutionary relationships.

With this purpose in mind, a collection of about 2100 skulls was made and prepared for study, chiefly by the junior author, during the winters of 1939–40 and 1940–41. The material was drawn from several points along a range of some 250 miles between the extremes of the eastern and the western Louisiana marshes. In the course of a preliminary (unpublished) investigation of 2092 specimens made by Kreeger, observations were recorded on body length, sex ratio, incidence of pregnancy, and skull dimensions based on four skull measurements. These observations indicated that body and skull size increased from the eastern toward the western part of the range. The sex ratio of the trapped animals was 117 males to 100 females. Eleven and nine-tenths per cent of the females could be identified as pregnant from a gross examination of the uterus, with an average of 3.7 embryos or fetuses per pregnant female. Since Mrs. Kreeger was unable to continue work with this material, the subsequent study has been done by the senior author.

Judging by the size of the smallest pregnant females, most of the animals from which our skull collection was made must be considered reproductively adult. Examination of the material, however, showed great variability in age, evident from the differences in the molar teeth, the external skull characters, and the density of the bone. For accurate analysis it is necessary to take account of relative age, as Dice (1932) has emphasized in the case of the deermouse.

Data on the length of prenatal and early postnatal life in muskrats are available (Errington, 1937, 1939; Svihla and Svihla, 1931), but the length of the adult life is unknown. Only a few of the muskrats banded and released by Mr. Ted O'Neil of the Louisiana Department of Wildlife and Fisheries (personal communication) have been recovered. The last one reported was brought in three years after its release as a young adult. It is unknown whether growth of body and

skull continues throughout life. The importance of this matter in taxonomic and ecological studies is indicated in the quotation from Allen above.

It seemed advisable, therefore, to make a preliminary study of skulls selected for evidences of advanced age and presumably completed growth changes. Three hundred fifty-seven such skulls were found in the collection, 158 males and 199 females. This paper deals with the dimensions and proportions of only the aged skulls. The criteria for their selection will be described later.

Sources of material.—The entire sample of about 2100 specimens was acquired in the form of skinned carcasses of animals trapped during December, January, and February of 1939–40 and 1940–41. Much of the material was obtained directly from the trappers as they skinned the animals. Some of the collections from the more distant parts of the state were shipped to us in large drums of weak phenol solution.

Specimens were taken from several localities: in southeastern Louisiana, one sample from the vicinity of Delacroix Island, in the swamps on the border between Plaquemines and St. Bernard Parishes, and one from a trapping camp on Gentilly Highway, within the city limits of New Orleans; in south-central Louisiana, from the region near Abbeville in Vermillion Parish; in the southwest, from two localities in the Sabine wildlife refuge in Cameron Parish, one near Sabine Lake on the Texas–Louisiana border, and one in the area near Calcasieu Lake some thirty miles eastward from the first. Co-operation of several agencies and individuals, to whom we are greatly indebted, made the collection possible. We wish especially to acknowledge the assistance of the following: Mr. W. P. Smith of the Farm Security Administration; Mr. Harry Adams of the U. S. Fish and Wildlife Service; Mr. Armand Daspit and Mr. Felix Nunez of the State Conservation Department (now the Department of Wildlife and Fisheries); and Mr. Richard Gordon of the Audubon Society.

Preparation of material.—The bodies were sexed and the females examined internally for pregnancy. Body length, from the tip of the nose to the posterior end of the pelvis (thus, not including the tail), was measured to the nearest centimeter by stretching the rats on a marked board. The heads were then tagged, removed, and the flesh allowed to decompose under bacterial action until it could be washed away from the skull. The skulls were dried at room temperature. The mandibles belonging to the skulls were saved in a majority of the cases, but those which became detached and intermingled with others during maceration were discarded.

Criteria for selecting skulls of aged individuals.—With the recognition that a study of adult skull variation necessitates restriction of the population sample to a definite age-range, and with the decision to consider first the skulls of animals which were at or near the end of adult age-changes, some arbitrary criterion for selecting old skulls had to be found. Age-changes in the muskrat appear to be continuous and of the same nature as in many other rodents (Allen, 1894; Howell, 1924; Merriam, 1895). The skull increases in weight and density, the dorsal contour becomes less convex, and the surface becomes roughened by local prominences. In particular the postorbital process of the squamosal is exaggerated,

the lambdoidal ridge becomes higher and sharper, and often small bony "horns" project forward at the junction of parietal and squamosal on the dorsal surface. Plate I shows the external appearance of the aged skull from two views. Sutures are generally distinct even in the oldest specimens.

The molar teeth undergo progressive changes throughout life and their condition is probably the most reliable indication of relative age. The crowns of the three hypsodont molars on each mandible are fluted columns. The fluting is obviously caused by the shape of the enamel organ. As the neck of the tooth is formed, the fluting is obliterated. When the roots appear, the smooth neck of the tooth is pushed gradually toward the surface. The roots elongate, the crown is worn down by use, and the entire tooth moves from a deeper to a more superficial position. Eventually the unfluted neck of the tooth appears outside the socket at the alveolar margin.

Since visibility of the end of the fluting of the tooth as it sits in the socket, in the dried skull, is almost always associated with other indications of advanced age in the skull, it affords a convenient and definite, though arbitrary, criterion for selecting old age skulls. The 357 skulls measured for this report were selected with particular attention to the first upper molar since this tooth is usually the first of the uppers to show the exposed lower end of the grooves. The first molar of the lower jaw may show the end of the fluting before any of the upper molars do, but, since some of the mandibles had been lost, the lower jaws were not used in the selection. Plate II shows the right upper molars of three old skulls with progressively more advanced tooth-changes. The bone of the outer alveolar wall has been chipped away to show the entire teeth in place.

Frequency of aged individuals.—The incidence of skulls showing advanced age varied, in different localities, from 6 per cent to 40 per cent of the entire sample taken in a locality. The highest percentage came from the Sabine Lake area near the Texas border. There is a possibility that in one of the collections shipped to us there may have been a selection for size. A number of other possible factors in this variability, however, have been suggested by Mr. Ted O'Neil (personal communication). Among them are: differences in the size of the area owned or leased by the trapper, and consequently in the intensity of trapping; differences in the type of trap used and in the way it is set; differences in the salinity and water level in the marshes, with consequent differences in food and predators. Influences other than the above may affect the proportion of animals which survive to old age.

The relative number of the two sexes among the old animals (158 males to 199 females) is not indicative of the sex ratio in the entire collection, which, as stated above, is 117 males to 100 females. Other reports of sex ratios in trapped muskrats usually give a similar high percentage of males (Buss, 1941; Hatfield, 1939; McCann, 1944; Marshall, 1937).

Embryos or fetuses were found in forty-four of the old females (22.1 per cent). Pregnancy was almost twice as frequent in this older group as in the total 1040 females examined by Kreeger. Perhaps some of the animals in the whole sample were not yet sexually mature or at least were affected to some degree by "adoles-

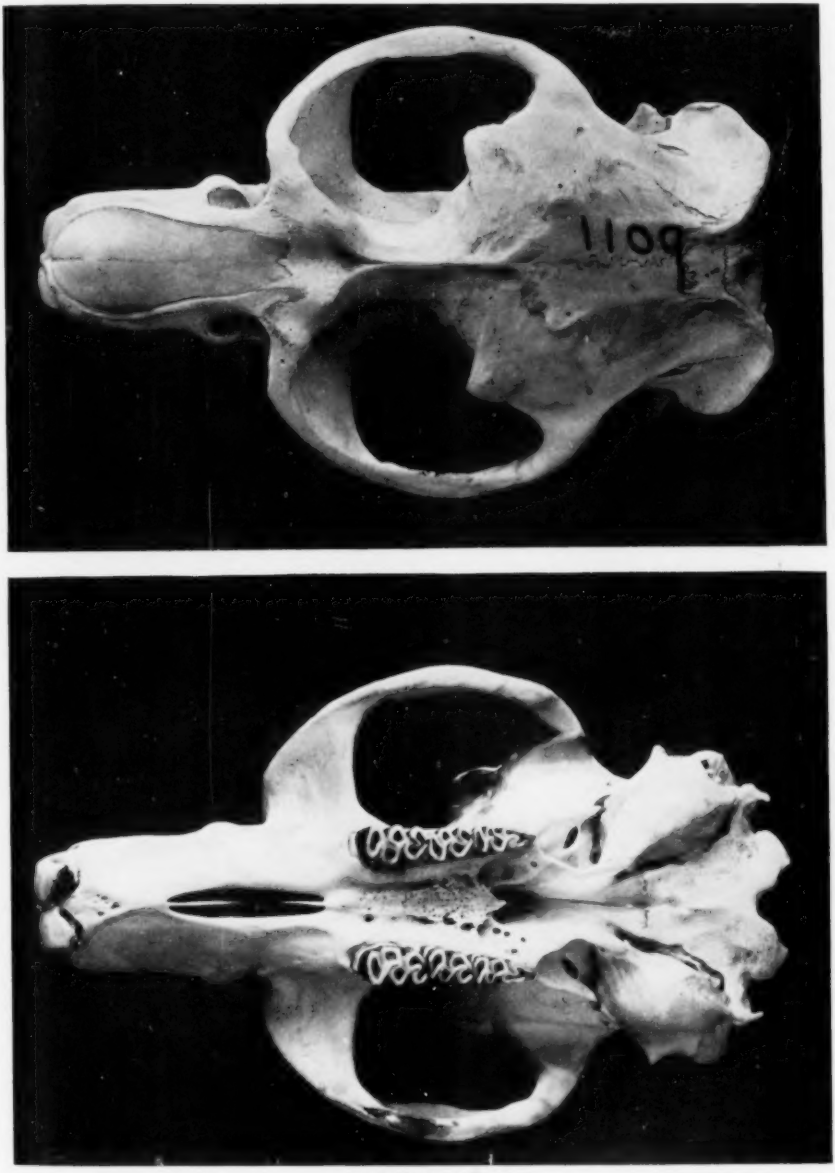

PLATE I

Dorsal and ventral views of the skull of an old male muskrat from Cameron Parish, La. Total length, 71.5 millimeters

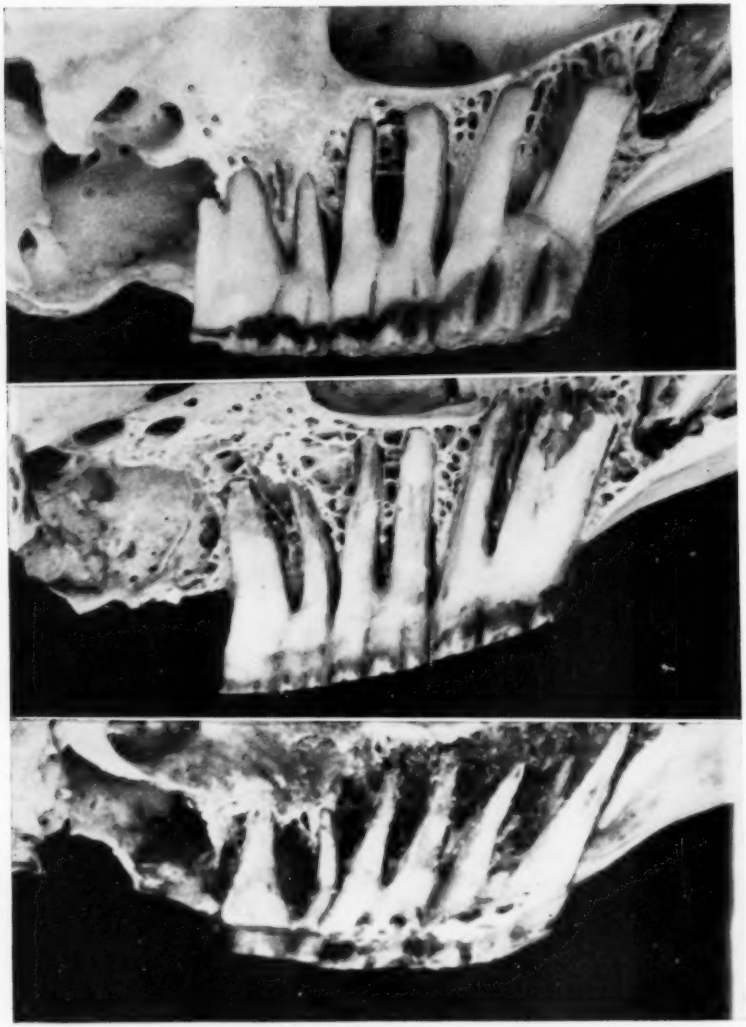

PLATE II

Right upper molars of three muskrats of advanced ages, from lateral view. Bone has been chipped away to expose the teeth in situ. The three figures illustrate the range of conditions in the sample studied

cent sterility." The mean number of embryos per female was not significantly different in the older animals.

Method of measurement of skull dimensions.—Measurements were taken with a

dial caliper, reading to one-tenth millimeter, while the skull was held firmly in any desired position by a spring clamp. Ten different dimensions of the skull were taken, as described below. The points of reference were chosen mostly according to Thomas (1905), though the works of others on skull measurement of rodents have been utilized (Donaldson, 1924; Howell, 1924 and 1926; Goin, 1943). The dimensions were chosen with the object of disclosing the relations of length and breadth in various regions and roughly differentiating splanchnocranial and neurocranial regions. All length measurements not in the mid-line were made on the left side. The reference points and axes of measurement are indicated in Figure 1. The dimensions are as follows:

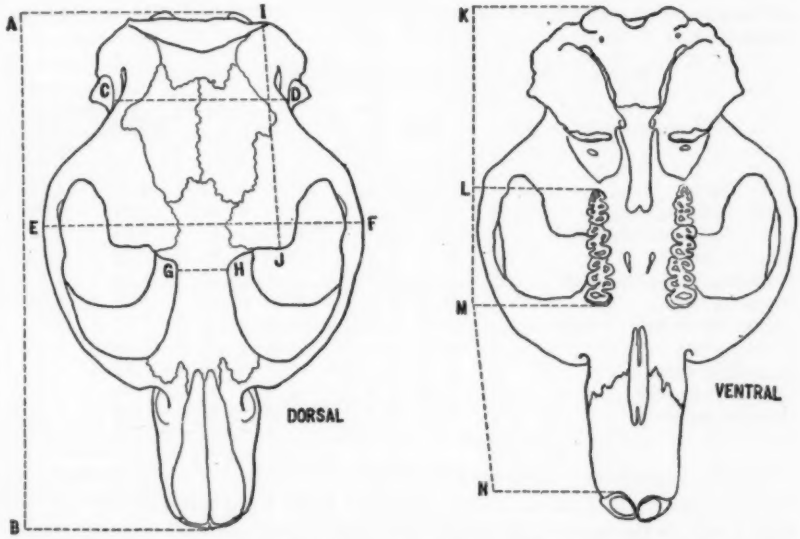

FIG. 1—Skull measurements: A–B, total skull length; C–D, cranial (post-zygomatic) width; E–F, zygomatic width; G–H, interorbital width; I–J, cranial (brain case) length; K–L, condylo-postalveolar length; K–M, condylo-alveolar length; L–M, alveolar length; M–N, diastema length.

(1) Total (condylobasal) skull length: most anterior point of the premaxillae (or anterior surface of incisors if more prominent) to condylions.

(2) Condylo-alveolar length (Goin, 1943): anterior margin of molar alveolus to condylion.

(3) Alveolar length: anterior margin to posterior margin of upper molar alveolus; length of molar tooth row.

(4) Condylo-postalveolar length (authors' term): condylo-alveolar length minus alveolar length; distance from posterior margin of upper molar alveolus to corresponding condylion.

(5) Length of diastema: henselion (posterior margin of alveolus of incisor) to anterior margin of molar alveolus.

(6) Cranial (brain case) length: from anterior surface of most prominent point of postor-

bital process to posterior surface of corresponding occipital below lambdoidal ridge. This measurement approximates the length of the brain box.

(7) Cranial (post-zygomatic) width: least distance between outer surfaces of the small bars of the squamosal behind the zygomatic arch. This measurement does not give the full width of the brain case, but there is no definitely located point from which the full width can be taken.

(8) Zygomatic width: greatest distance between the outer surfaces of the zygomatic arches.

(9) Interorbital width: least distance between the orbits, taken with the fine points of the calipers.

(10) Occipital height: vertical or nearly vertical distance from the basion to the highest point of the supraoccipital, in the mid-line.

The condylo-basilar length of Thomas (1905), from the henselion to the condylion, has not been included, but would be equal to the condylo-alveolar length plus the diastema length.

TABLE 1.—*Body length and skull dimensions, millimeters*

DIMENSION	RANGE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION, PER CENT
Body length	250.0-330.0	296.72 ± .75	14.14	4.76
Total skull length	58.8- 72.3	65.47 ± .14	2.65	4.05
Condylo-alveolar length	34.0- 43.4	38.69 ± .09	1.68	4.35
Alveolar length	13.5- 17.7	15.93 ± .04	.72	4.49
Condylo-postalveolar length	18.3- 26.8	22.78 ± .07	1.34	5.89
Diastema length	19.9- 25.3	22.53 ± .06	1.10	4.90
Cranial (brain case) length	24.6- 30.9	27.62 ± .06	1.12	4.05
Cranial width	19.7- 24.8	22.26 ± .03	.82	3.68
Zygomatic width	36.2- 45.3	40.88 ± .10	1.81	4.43
Interorbital width	4.2- 7.9	6.29 ± .03	.56	8.93
Occipital height	14.7- 18.8	16.68 ± .04	.79	4.72

Absolute dimensions.—Data on body length and the dimensions of the skull are brought together in Table 1. All constants in Table 1 are based on 357 individuals, except in the case of zygomatic width (348 individuals) and occipital height (355 individuals). The standard error is used as the measure of reliability throughout the paper. Previously, some body measurements on five specimens were made by Bangs (1895), who originally named the Louisiana muskrat, and a few body and skull measurements on ten specimens were made by Hollister (1911). Hollister's mean dimensions, where comparable with those of this study, agree fairly well with ours and suggest that his specimens were fully adult and probably of advanced age. Latimer and Riley (1934) give mean dimensions for about 124 skulls of *O. zibethica cinnamomina* (Hollister) from Kansas. Their material was selected for maturity in a different way than ours (absence of epiphyseal lines in long bones) and the specimens were probably not as old. Mean skull length, alveolar length, and zygomatic width are significantly greater in our aged muskrats than in the Kansas material. Length of diastema and cranial width are nearly the same in the two groups; but interorbital width is less in the Louisiana muskrats, if the techniques of measurement were the same. It is inter-

esting that differences in mean skull dimensions between samples from different regions of Louisiana (see below) are often greater than between the means of the total group here reported and the means of the *O. z. cinnamomina* sample from Kansas.

Sexual differences.—The writers have so far found no criterion by which the sex of an individual can be diagnosed from the skull. Hollister (1911) stated

TABLE 2.—*Body length and skull dimensions by sex, millimeters*

DIMENSION	MALES		FEMALES		DIFFERENCE AND ITS STANDARD ERROR
	No.	Mean	No.	Mean	
Body length	158	299.2	199	294.8	4.4 ± 1.47
Total skull length	158	66.33	199	64.82	1.51 ± .26
Condylo-alveolar length	158	39.21	199	38.27	.94 ± .17
Alveolar length	158	15.96	199	15.92	.04 ± .07
Condylo-postalveolar length	158	23.27	199	22.41	.86 ± .13
Diastema length	158	22.88	199	22.24	.64 ± .11
Cranial (brain case) length	158	27.94	199	27.37	.57 ± .10
Cranial width	158	22.47	199	22.09	.38 ± .06
Zygomatic width	155	41.43	193	40.44	.99 ± .18
Occipital height	158	16.90	197	16.51	.39 ± .08

TABLE 3.—*Body length and skull dimensions, by regions, millimeters*

DIMENSION	EASTERN LOUISIANA		MIDWESTERN LOUISIANA		WESTERN LOUISIANA	
	No.	Mean	No.	Mean	No.	Mean
Body length	89	283.5 ± 1.3	46	293.7 ± 1.5	222	302.7 ± .76
Total skull length	89	62.83 ± .21	46	64.07 ± .27	222	66.85 ± .13
Condylo-alveolar length	89	37.20 ± .14	46	37.80 ± .18	222	39.47 ± .09
Alveolar length	89	15.60 ± .07	46	15.71 ± .15	222	16.11 ± .05
Condylo-postalveolar length	89	21.60 ± .12	46	22.12 ± .14	222	23.39 ± .07
Diastema length	89	21.65 ± .10	46	21.89 ± .12	222	23.00 ± .06
Cranial (brain case) length	89	26.73 ± .10	46	27.20 ± .15	222	28.07 ± .06
Cranial width	89	21.57 ± .07	46	21.81 ± .09	222	22.63 ± .05
Zygomatic width	87	39.41 ± .17	43	40.06 ± .21	218	41.63 ± .10
Interorbital width	89	6.14 ± .05	46	6.29 ± .07	222	6.35 ± .04
Occipital height	89	16.20 ± .07	46	16.31 ± .11	222	16.95 ± .05

that no sex differences can be determined by measurements. Nevertheless, when sufficient numbers of skulls from animals of known sex are assembled, mean differences in favor of males are found in every dimension except interorbital width, for which the two sexes were not compared. All the differences except alveolar length are statistically significant. Table 2 gives statistical constants for the two sexes separately.

Regional differences.—When the 357 specimens are grouped according to their

geographical origin, from the eastern, middle western, and western parts of the Louisiana range, as described above, the averages by regions demonstrate an increase in absolute skull dimensions from east toward west, as shown in Table 3. With the exception of alveolar length and interorbital width, the differences are significant, being from two to nine times their standard errors. The shape of the skull, however, does not appear to differ among the regional groups if one compares samples having the same absolute size. This was demonstrated by relating various mean dimensions to mean skull length. No evidence of genetic differences in the three regions of the range has appeared so far. The size differences may be due to environmental causes. Conditions are not identical throughout the range. Variations exist in the degree of salinity of the marsh, in the relative abundance and kind of food, and in the number of predators such as mink and otter. Size differences are important, however, from an ecological standpoint and because they enter into considerations of taxonomic status.

TABLE 4.—*Correlations between dimensions*

DIMENSIONS	COEFFICIENT OF CORRELATION
Skull length and body length	.82
Skull length and condylo-alveolar length	.93
Skull length and diastema length	.85
Skull length and alveolar length	.53
Skull length and condylo-postalveolar length	.89
Skull length and cranial (brain case) length	.72
Skull length and zygomatic width	.83
Skull length and cranial width	.67
Skull length and interorbital width	.13
Skull length and occipital height	.68
Condylo-alveolar length and diastema length	.63
Cranial width and zygomatic width	.66

Skull proportions and absolute size.—The degree of constancy of skull pattern among the individuals of this total sample of old skulls may be indicated by coefficients of correlation between pairs of skull dimensions. Table 4 gives the coefficients of correlation between skull length and other skull dimensions, and between cranial width and zygomatic width. Most of these coefficients are high, indicating homogeneity of the sample. Interorbital width, however, is very erratic and is not closely correlated with skull length or with any other skull dimension taken. The correlation of alveolar length with skull length is not very high, obviously, because the size of the molar teeth, and consequently the length of the tooth row, is determined at an early period and would not be much affected by variations in the postnatal development of the skull. The molars in young animals are long, fluted prisms, with the base of the crown (the last part formed) only a little thicker than the top. The fact that the correlation is as high as it is, .53, indicates that at the time the enamel organ is active there is a relation between its size and the size of the head.

The length of the skull is closely correlated with the length of the body, the coefficient being .82.

Coefficients of correlation do not bring out the change in shape accompanying differences in absolute size of the skull in this advanced age group. We have therefore plotted against the classes of total skull length the means of other dimensions for the individuals in those classes, expressed in terms of percentage of skull length, and will refer to the percentages as "relative" dimensions. The trends of mean relative dimensions with increasing skull length are shown in Figure 2.

Relative diastema length and relative condylo-alveolar length remain almost constant with increasing skull length; that is, the rostrum and the base of the skull posterior to it retain approximately the same relations to total skull length. Relative alveolar length decreases, undoubtedly because of the early determination of the size of molar teeth. Since relative condylo-postalveolar length is the component of condylo-alveolar length left after subtracting alveolar length, it must rise as alveolar length falls, with increasing skull length. The relative brain case length, a dorsal dimension, falls off with increasing skull length as does the relative cranial width. The relative occipital height also declines somewhat. It is clear that the basal and facial part of the skull takes a greater part in the make-up of the large skulls than it does in the smaller ones. The relative zygomatic width and the relative interorbital width decline appreciably. Since all the relative width measurements and the relative occipital height fail to keep pace with skull length as it increases, it is obvious that the large skulls are somewhat narrower and lower, relatively, than the small ones. In the larger skulls, the dorsal contour is flatter, both antero-posteriorly and transversely, but this is a matter of observation which has not been expressed in figures. It can also be stated, though not shown on the charts, that the relation of zygomatic width to cranial (post-zygomatic) width remains constant up to a cranial width of about 22 millimeters, beyond which zygomatic width begins to increase more than cranial.

It should be kept in mind that these measurements have been made on a selected sample of skulls representing animals in an advanced period of life. The meaning of the changes in skull proportions with increasing skull size in old animals will be clearer when a further study, dealing with the skulls of younger adult and adolescent animals, has been completed.

Summary.—A craniometric study is made of 357 specimens of the Louisiana muskrat. From the condition of the teeth, these are judged to be long past maturity. It is concluded that: (1) There is a great deal of variation in absolute body and skull size of animals in the same age-range, so much as to indicate that fairly large collections of small mammals are desirable where mean dimensions are used for taxonomic purposes. (2) Small but significant mean size differences are found between males and females, though no diagnostic sex differences have been found in individual skulls. (3) A geographic cline of increasing body and skull size extends from the eastern toward the western part of the continuous range in the Louisiana marshes. No geographic difference in skull shape has been found except as related to skull size. (4) Skull proportions change with increasing total

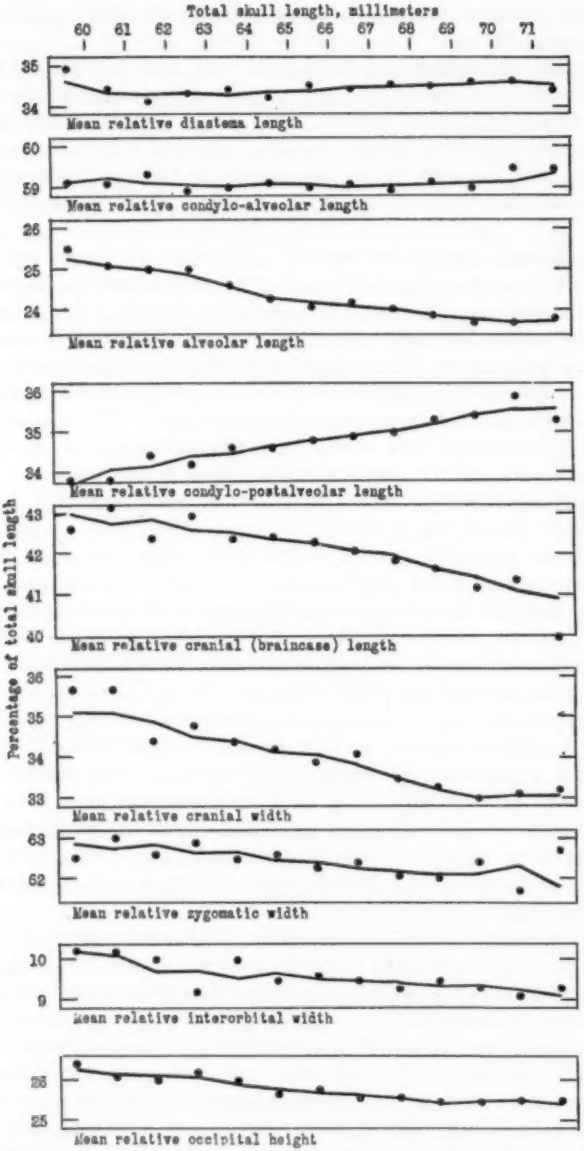

FIG. 2.—Relations of various dimensions to skull length. Dots indicate actual percentages of skull length, solid lines represent trends and are smoothed by the method of weighted moving averages.

skull length. Basal and facial length measurements increase consistently with skull length, but the brain case fails to maintain the same relative size, and the relative width of the face decreases slightly.

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THE EARLY POSTNATAL DEVELOPMENT OF THE BRAIN OF THE OPOSSUM (*DIDELPHIS VIRGINIANA*)

By W. Riese

As shown in a previous paper (Riese, 1945), after a gestation period of twelve and three-fourths days, the opossum is born without any cortical structure. Immediately after birth, it reaches by its own efforts the pouch of its mother where it remains for some fifty days (McCrady 1938). The following observations on the early post-natal development of the brain of the opossum were made on five pouch-young animals, 16, 16 to 20, 22, 35, and 53 days old. With the exception of the second specimen, the material was given by Dr. Carl R. Moore (Department of Zoology, University of Chicago) to whom I wish to express my gratitude. The so-called cortical layer (His) or *lamina granularis primaria* (M. Rose), primordium of the mammalian cerebral cortex, was found in the sixteen day pouch-young opossum. In the human, this layer is not detectable before the third month of intra-uterine life, but it is still present in the bear (*Ursus arctos* L.) at the time of birth, after a gestation period of 208 days (Riese, 1942).

In comparing the external features, behavior, and brain of a pouch-young opossum having an estimated age of sixteen to twenty days (body length, 30 mm.; head length, 15 mm.; and fresh weight, 2 grams) with the new-born opossum (stage 35 of McCrady, 1938, fig. 55), the neck has become much smaller, the upper extremities less prominent, and the hind limbs more differentiated. The entire body appears to be a much more articulated whole than at the time of birth and the anlagen of eyes and ears are conspicuous (Pl. I, Lower). In view of the brief interval between birth and this stage, the progress made in the differentiation of the external features must be considered as considerable. After removal from the nipple of its mother, the animal was very active. No definite righting reflex was present. The animal succeeded only occasionally, and only for a very short time, in righting itself or rather in turning over from its usual position of lying on one side. According to O. R. Langworthy (1928), the righting reflex appears in a fifty-four day old opossum. There were constant and alternate movements of the extended fore limbs; the toes were also in extension. The hind part of the trunk was flexed, adducted towards the upper trunk, and sometimes rotated (obviously in a vain effort to produce righting). There were also movements of the hind limbs, rarely alternate, but mostly synchronic in rhythm. The hind limbs were extended and abducted. There were extensive movements of the head which was elevated, but the side to side movements so characteristic of the newborn could not be seen. There was no detectable reaction to pin prick applied to various parts of the body. In some respects, the behavior of this specimen was similar to that of 27 mm. pouch-young opossums observed by O. R. Langworthy (1928), in others not, but the estimated age of Langworthy's animals remained doubtful.

The structure of the hemispheric wall of this specimen was basically the same as that of the sixteen day old pouch-young opossum. Marginal layer, cortical layer, intermediate layer, and matrix could easily be distinguished. The cortical

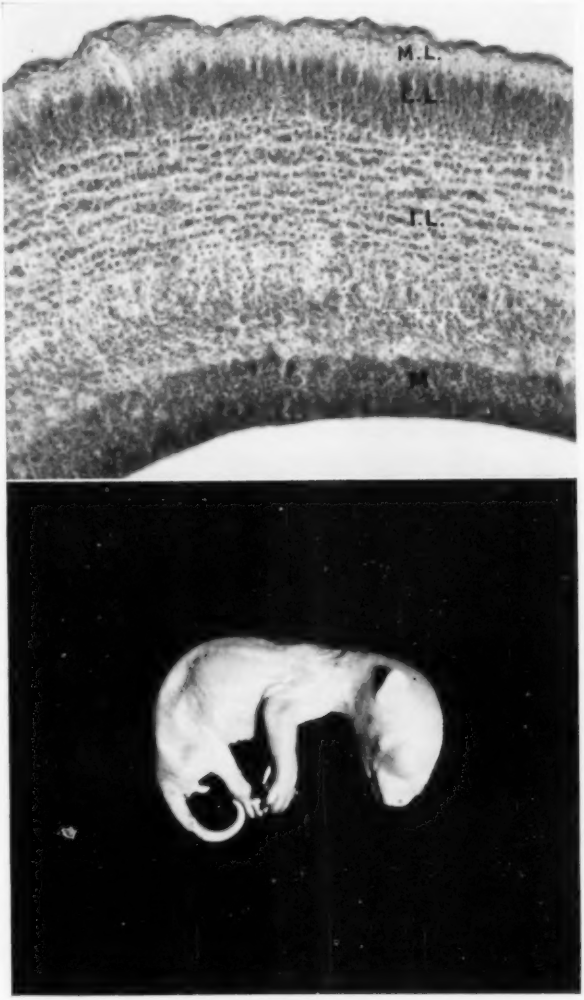

PLATE I

UPPER: Structure of hemispheric wall of young opossum shown below. Hematoxylin, x 400. M. L., marginal layer; C. L., cortical layer; I. L., intermediate layer; M., matrix

LOWER: External features of pouch-young opossum, sixteen to twenty days estimated age

layer was still unstratified (Pl. I, Upper). In the interval between these two stages, and while no basic change took place in the hemispheric wall, the pouch-young opossum brings its basal ganglia to their first development; a similar

"alternate growth of cerebral structures" was described by the writer in the human (Riese, 1938). No further progress in brain development was seen in the twenty-two day pouch-young opossum. In the thirty-five day pouch-young opossum, signs of *cortical lamination* could be seen, i.e., a denser superficial and a more loose deep layer, the cells being more mature in the deep layer. According to O. R. Langworthy (1928), there was almost no myelinization as yet of fibers in the spinal cord of a thirty-six day opossum. The animal was "active, displaying a considerable amount of reflex activity." This stage corresponds to a three to four month human embryo. In the fifty-three day specimen, the basic tectogenetic *cytoarchitectural type* of the mammalian cerebral cortex was obvious, and even *regional variations of the six layer type* were found, pyramidization (area 4 of Brodmann) and granulization (area 17) making their first appearances. This stage of cortical development corresponds to that of a six to eight month human embryo. In none of these early postnatal stages did the cortex contain neurofibrils. The highest level at which neurofibrils could be brought out was the intermediate layer (primordium of the white substance) of the hemisphere, and the earliest stage revealing neurofibrils at this level was thirty-five days. There were no neurofibrils in the central nervous system of the sixteen day pouch-young opossum; the highest level showing neurofibrils in the twenty-two day specimen was the midbrain. The structure of the individual cell, studied by using the criteria of cell maturation as adopted by Riese and Smyth (1940), was still unfinished in the cortex of the fifty-three day opossum. The highest level at which relatively mature nerve cells could be seen in this specimen was the midbrain.

Conclusion.—The *rapidity of growth*, so obvious in the pre-natal development of the brain of the opossum, continues after birth. If the cerebral cortex contributes to nervous function in the pouch-young opossum, it can only rely on immature nerve cells and it has no neurofibrils as conveying mechanisms. The law, announced previously (Riese, 1944), that the developmental stage reached by the mammalian brain at a given moment of intra-uterine life or at birth is *not proportionate to the gestation period* holds true for the prenatal as well as the postnatal development of the brain of the opossum. The youngest pouch-young opossum whose motor cortex was stimulated by O. R. Langworthy (1927) was twenty-three days old. On electrical stimulation of three areas along the sagittal fissure, movements of the contralateral foreleg were obtained, the predominating factor being an extensor thrust of the whole leg with outspreading of the toes. Exploration of the rest of the cerebral cortex, with stronger currents, failed to elicit any movements of either the facial-masticatory musculature or of the hind legs. The criterion according to which the author considered the region stimulated as the motor area was the depth of the molecular layer. The picture given by the author represents a still unstratified cortical layer similar to that of our twenty-two day pouch-young opossum. As the author states himself "supragranular and infragranular pyramidal layers cannot be clearly differentiated in this section." He concluded: "The cortex at this time appears very immature so that it is difficult to correlate the histological picture with the clear-cut responses obtained from electrical stimulation." I found no regional variations

in the cortical layer of a twenty-two day pouch-young opossum. On the ground of this negative statement, the experimental evidence of foreleg movement in a twenty-three day pouch-young opossum gains extraordinary importance. It shows that parts of the body can be thrown into action selectively, regardless of a still universal immaturity of the cortical structure. The conclusion must be drawn that the criteria according to which electrically induced motor functions first appear in the cortex are physiological rather than anatomical ones, movements of the forelegs probably being the most important ones at this developmental stage of the animal; thus the first ones to be elicited by stimulation. Although a negative effect of decerebration proves only that the animal can renounce the higher levels in case of emergency, not that the activity of the central nervous system is an exclusively spinal one in the intact animal, it still remains interesting to know the effects of decerebration in young opossums. No data are available as to decerebration effects in new-born opossums. The first suggestion of a response to decerebration appeared in animals having a nose-rump length of 49 mm. (Langworthy, 1928). Strong extension of the forelegs occurred in a young opossum fifty-four days old and 77 mm. long. At this stage the forebrain is still immature, particularly as to the structure of the nerve cells (according to O. R. Langworthy the vestibular connections and the mesencephalic part of the rubrospinal tract are already myelinated). Increased activity and prolonged progressive movements were evident after decerebration of an opossum having 82 mm. nose-rump length and fifty-six days of age. After decerebration of a 151 mm., 76 day opossum, the extensor tone became so increased that progressive movements were inhibited and the reflex activity of the animal was decreased.

General significance.—To realize the full significance of the behavior of the pouch-young opossum and of the central structures related to this behavior, we must keep in mind that the pouch-young opossum cannot be looked upon as an ordinary mammalian embryo since in the latter no spontaneous and purposeful activity occurs which later subsides. Nor is the pouch-young opossum simply a mammal at an early postnatal stage since the mammalian infant shows almost constant motion, purposeful or not, while the pouch-young opossum becomes so securely attached to its mother's mammary nipple that it cannot detach itself for some fifty days (McCrady, 1938). Thus, after a brief episode of spontaneous and purposeful motor activity, by means of which the new-born opossum reaches the pouch by its own efforts, it re-enters a new and long period of inactivity. It continues however to grow and to differentiate its nervous structures. By its passing from intra-uterine to extra-uterine life, an embryo passes not only from dependent to independent existence, but it has from now on to rely on stimulations coming from its new environment as an indispensable condition for further growth and development. As a rule the central nervous system of the mammalian infant seems well equipped to receive those stimulations and to react to them in an appropriate manner. This activity was previously believed to be a growth facilitating factor. However, there are experimental evidences that growth may go on in an immature mammalian nervous system submitted to long enduring

inactivity (Tower, 1937). The functional and structural behavior of the pouch-young opossum can be considered as a natural experiment showing that the arrest of a previously displayed spontaneous and purposeful activity does not stop growth and further differentiation of nervous structures In this species, stimulations from outside are certainly reduced in number and most uniform in character; they are not major factors in postnatal development and growth; the intrinsic factors obviously being by far dominant. G. E. Coghill (1929), though admitting surrounding conditions as growth determining factors, held that growth as such must be regarded as the expression of an intrinsic potentiality of the cell and that nervous function or exercise cannot be either directly or indirectly the cause of growth and differentiation of the nerve cell. After cutting all posterior roots in the lumbo-sacral region, and transecting the cord above and below in puppies, Tower (1937) saw all ordinary activites, including muscle tone, abolished; the cord continued to grow. She referred to the earlier work of R. G. Harrison (1904) who eliminated the effect of functional stimuli (on growing frog larvae) by operative and chemical procedures. In spite of the removal of the medullary tube, the grouping of the fibers into individual muscles took place, the hind legs developed fully as regards outward form (they had however an atrophic appearance and no voluntary movements were ever observed, nor could any response to mechanical or electrical stimulation be obtained). The quick acquisition of the power to carry out the movements of swimming and respiration (after removal of the drug) showed that the mechanisms in question developed in perfect order without the influence of normal function. Harrison referred to Schaper's experimental proof that the brain as a nerve center exerts no general formative influence upon the development of the organism as a whole.

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APPLIED ECOLOGY OF PREDATION ON LIVESTOCK RANGES

BY CLIFFORD C. PRESNALL

Zoological research, aside from the works of Sperry (1941), Young (1946), and Young and Goldman (1944, 1946) is notably deficient in studies of predation upon domestic species. The subject too often has been dismissed with the casual assumption that a domestic prey species is an extraneous factor that interferes with accurate appraisal of so-called natural predation. Such a viewpoint is akin to the attitude that man is an unnatural element in mammalian ecology.

Civilized man and the species domesticated by him are responsible for profound and rapid adjustments in ecological patterns that presumably had been comparatively stable prior to the relatively recent dominance of mankind over wilderness conditions. The active conflicts of these adjustments are most evident in those parts of the world that might be termed ecological frontiers, such as the African veldt, or the grazing lands of western North America, where great numbers of domestic animals and large predators range together with relatively slight restraint on either group.

According to latest statistics (U.S.D.A. 1936, 1945), it is estimated that approximately 19,300,000 animal units of domestic livestock are now annually supported on about 728 million acres of uncultivated grass, brush, desert, and forest collectively known as the western range of the United States (based on forage consumption, five sheep or goats are considered equivalent to one cow or horse). On the basis of estimates by Jackson (1944), it is computed that these lands also provide forage for approximately 900,000 animal units of species herein designated as "big game"—deer, elk, moose, antelope, big-horn sheep, mountain goats, and javelina. Accurate population estimates are not now obtainable for the large predatory species capable of preying upon livestock and big game, but their relative abundance may be indicated. Wolves and lynx are now so rare in the range country that they may be omitted from this discussion. Bobcats, although locally common, may also be omitted because of their relative inefficiency as predators upon grazing animals, other than the lambs of domestic sheep. Bears, exclusive of the rare grizzlies, are locally common, but can scarcely be classed as predators upon grazing animals except under certain circumstances. During poor mast years many bears tend to prey on livestock and big game; similar tendencies are observed where heavy populations of bears and potential prey species exist on the same range; and individual bears at times appear to acquire a habit of feeding to a considerable extent on big game or livestock.

Cougars are now uncommon or rare, but are capable predators upon all the grazing species under certain conditions, hence, are an important factor wherever present. They now live chiefly in rough and heavily timbered areas where their elusive habits add greatly to the difficulty of accurately estimating their numbers. Forest Service estimates have placed the total western population of cougars at from 5,000 to 6,000, with no pronounced fluctuations during the past twenty years. This estimate belies their importance in the ecology of the western range. An individual cougar may cover a distance of over twenty-five miles in a single night's hunting, and may eat the equivalent of one deer per week (Young and Goldman, 1946). Adult cougars with little exercise, fed by the writer while in captivity, consumed about ten pounds of fresh meat daily. Although cougars are notorious killers of all kinds of livestock, their principal food is deer (Young and Goldman, 1946). Their heavy predation upon deer tends to reduce violent fluctuations in deer populations (Leopold, 1943; Rasmussen, 1941), and scarcity of deer increases their predation upon livestock (Hamilton, 1941).

Coyotes are by far the most numerous of the large predators, but population data are inadequate for making more than a rough guess as to total numbers in the range country. Maximum densities are surprisingly high under favorable conditions. On cattle range in the San Carlos Indian Reservation, Arizona, where little hunting or trapping had been practiced for several years, there was an estimated population of forty-nine per township (Presnall and Rush, 1941). Subsequent heavy trapping indicated that this estimate was conservative. Under somewhat similar conditions on the Sitgreaves National Forest, Arizona, a population of eighteen coyotes per township was estimated (Mercer, 1947). In contrast, there are a few sizeable range areas in which coyotes are very rare or absent. The largest of these is in south-central Texas, where an area of 30,000 square miles has been kept practically free of coyotes since 1932. In half of this area reasonably complete control has been in effect for twenty or more years (Landon, 1947). A clue to the total number of coyotes in the western range states is furnished by the annual take. In 1946, the recorded take by Federal and State hunters and by bounty hunters totalled 294,400. It is likely that there was little additional take by fur trappers who did not collect bounty; fur prices have been very low since 1943. An analysis of annual takes by the Fish and Wildlife Service during the past fifteen years, as shown in Table 1, leads to the inference that the total annual take did not equal the annual increase until recently, perhaps about 1942 or even later.

In addition to their outstanding ability to withstand heavy predation (hunting pressure) by man, coyotes possess very versatile food habits and an amazing capability as predators upon several grazing species. Horses and moose, except the very young or decrepit, seldom if ever fall prey to coyotes. Successful attacks on elk and cattle are limited to young calves or extremely feeble adults, but even here coyotes have demonstrated their versatility by gradually increasing their attacks during the years since wolves became rare. One of the earliest references to killing of domestic calves by coyotes is found in an unpublished report made in 1932 by C. R. Landon, then stationed with the Biological Survey in Texas. At that

time such predation was considered to be exceptional, but succeeding years have brought increasing numbers of similar reports. During the past year, 376 well authenticated cases of coyote predation on calves were reported to the Fish and Wildlife Service. Coyote predation upon grazing animals is directed chiefly against sheep, with goats, antelope, and deer next in importance. Sperry (1941) found that domestic livestock, chiefly sheep and goats, made up about one-seventh (13.59 per cent) of the food of coyotes; rabbits, 33.25 per cent; and rodents, 17.25 per cent.

The importance of rabbits and rodents in the diet of coyotes has suggested the possibility of a correlation between population cycles of coyotes and their smaller prey species, similar to predator-prey cycles known to occur in Arctic and sub-Arctic regions. There is widespread belief that coyotes prevent an over abundance of rodents. The writer has been unable to find any foundation for this belief. Studies of the Buena Vista mouse plague in California (Piper, 1928) show

TABLE 1.—*Annual take of coyotes by hunters supervised by the Fish and Wildlife Service*

YEAR	COYOTES	YEAR	COYOTES	YEAR	COYOTES
1916	12,013	1927	37,880	1937	80,299
1917	22,417	1928	35,709	1938	84.844
1918	26,145	1929	40,254	1939	93,093
1919	27,213	1930	39,492	1940	104,072
1920	21,558	1931	45,016	1941	110,495
1921	24,265	1932	52,254	1942	111,076
1922	27,186	1933	54,942	1943	103,981
1923	25,621	1934	50,929	1944	108,050
1924	34,092	1935	59,289	1945	102,979
1925	37,255	1936	64,566	1946	108,311
1926	35,619				

that the rapid rise and fall of mouse numbers was due to factors of environment, disease, and intraspecific strife that were so strong as to obscure any fluctuations attributable to the abundance of coyotes and other predators before and during the plague. Similarly, recent studies in central California (Fitch, 1947) show no correlation between population trends of coyotes and their common prey species, cottontails (*Sylvilagus audubonii*), ground squirrels (*Citellus beecheyi*), pocket gophers (*Thomomys bottae*), kangaroo rats (*Dipodomys heermanni*), and woodrats (*Neotoma fuscipes*). Early stages of this study were reported by Horn (1941). Citation of other similar observations is unnecessary since Errington (1946) has already assembled and discussed a large volume of corroborative evidence.

The amount of predation upon livestock and game is difficult to estimate. Sheep raisers have often used the rule-of-thumb calculation that predators, unless vigorously controlled, destroy about $1.00 worth of lamb and mutton per ewe per year. If ewes are worth $8.00 each, this rule roughly expresses the 10 to 15 per cent annual loss that is widely recognized for sheep ranging in areas where predators are not effectively controlled. Predation upon goats is slightly lighter,

due to their greater agility and combativeness. Predation on swine is locally severe at times, but is unimportant in the aggregate, as comparatively few swine run at large on range land. Cattle suffer light predation, perhaps between 1 per cent and 1.5 per cent on the average, now that wolves are practically absent and cougars and bears are localized. Horses, as a group, experience almost no predation, although local and sporadic attacks by cougars and occasionally bear may be severe. On the basis of these estimates, and allowing for sizeable range areas where effective predator control reduces livestock losses, it seems conservative to say that the annual loss by predation on all western range livestock is between 1.5 per cent and 2 per cent of the annual increase. Gross revenues from western range livestock in 1944 have been computed from latest available statistics (U.S.D.A., 1945) at approximately one and a quarter billion dollars, hence, the likely loss from predation in that year may be represented by an order of magnitude of twenty million dollars.

Since this discussion deals chiefly with livestock, no attempt is made to review the considerable amount of literature on predation in relation to big game. It should be apparent to anyone studying the problem, however, that total predation upon big game is unknown, even in terms of the rough approximation given for livestock. It is impractical or perhaps even impossible to observe wild game closely enough to determine all causes of death, particularly among the very young; and studies of game kept under close surveillance on fenced preserves are not typical of conditions in the wild.

The interwoven roles of predators, big game, rodents, and livestock are conditioned by man's maintenance of livestock at a fairly constant, high population level. Hence fluctuating numbers of big game and rodents cause an inverse ratio of predation upon livestock. This statement is based upon observations of many Fish and Wildlife Service hunters rather than upon statistics, which are not available. The relationship has been most readily apparent as regards rabbits, including hares. During years of high rabbit population, the reports of predation on livestock are consistently though not outstandingly fewer than when rabbits are scarce. It is often apparent that throughout North America there is a close relation between rabbits and predators, which results in fluctuating predator populations in northern Canada and slightly fluctuating predator pressure upon livestock in the western range area. Marked fluctuations in predator populations would not be expected and are not observed in the presence of an abundant supply of livestock. It may be that where game is somewhat scarce an abundance of domestic animals would tend to diminish predator pressure upon their less vulnerable wild cousins, although I do not recall any studies along this line. The high vulnerability of livestock would certainly have caused marked increases in large predators during the past century, except for man's heavy predation upon them. There is some evidence that one predator, the coyote, has actually increased in numbers despite man's vaunted superiority. Certainly there has been a considerable extension of coyote range eastward, and northward through Canada into Alaska (Seton, 1929; Sarber, 1944).

Some aspects of man's heavy predation upon the larger four-footed predators

have been sufficiently aberrant to justify doubt as to whether *Homo* is actually *sapiens*. For many years a great deal of effort and money has been expended to control predators on the western range, yet there has been no pronounced change in the basic ecological pattern. About eighty years ago, when livestock first began to supplant the great game herds of the western plains, it was found that the change could be profitably made only if accompanied by a reduction of predators. Today, with livestock utilization of forage exceeding that of game twenty to one on the western range, predators continue to jeopardize the practicality of this game-livestock shift unless well controlled. Predator control, excepting in the Texas coyote-free area, has been a "hold-the-line" proposition in which an

TABLE 2.—*Money paid for predator control, 1946*

STATE	SALARIED HUNTERS		BOUNTIES	TOTAL COSTS
	Federal Funds	State, County, and Other		
Arizona	$31,980	$38,553		$70,533
California	46,839	313,934	$37,970	398,743
Colorado	43,891	96,889	2,576	143,356
Idaho	42,189	83,479	27,026	152,694
Kansas			45,500	45,500
Montana	43,026	98,036	34,073	175,135
Nebraska	10,695	8,015	11,366	30,076
Nevada	44,639	45,767	1,675	92,081
New Mexico	42,390	81,270	1,870	125,530
North Dakota	15,385	18,194	115,348	148,927
Oklahoma	19,970	22,253	61,000	103,223
Oregon	49,601	95,881	46,194	191,676
South Dakota	2,100	1,282	244,047	247,429
Texas	57,890	259,325	27,021	344,236
Utah	9,160	36,423	137,875	183,458
Washington	20,863	41,591	56,509	118,963
Wyoming	45,200	98,117		143,317
Totals	$525,818	$1,339,009	$850,050	$2,714,877

impartial observer might conclude that mankind chose to spend nearly three million dollars annually (Table 2) to insure the doubtful privilege of having a sustained yield of coyote fur worth considerably less than a million dollars at current prices, and a sustained yield of livestock from which predators ate only about twenty million dollars worth annually.

The broad outlines of this blundering experiment, which has demonstrated the futility of trying to maintain sustained yields of coyotes, livestock, and big game on the same area, may be sketched as follows: Wolves, the most effective of western range predators, were the primary target of early-day control programs. During the first quarter of the present century they were reduced to extreme rarity (Young, 1946). Grizzly bears soon met a similar fate, and cougar populations were reduced drastically. But as the larger predators disappeared coyotes be-

came more numerous and bold (Ligon, 1927). They in turn became the primary target of control programs, and have held that position for the past thirty years. Records indicate that the annual take of coyotes during the first twenty-six years of that period probably has not exceeded the reproductive capacity of the species. In fact, it is entirely possible that the regular removal of the annual coyote crop has stimulated an increase in reproduction and extension of territory. Such an effect is especially apparent as regards coyote control by bounty hunters or fur trappers, partly because both groups are interested in perpetuating their means of livelihood and also find it unprofitable to hunt an area to the point where it no longer produces a sustained yield of coyotes (Hall, 1946).

If it should be decided to terminate the conflict on the ecological frontier of the western range, now being won by predators at a cost of some $22,000,000 per year, it probably can be done. The probability is based upon results that attended a limited use of several new control methods during the past year and upon what has been done in the coyote-free area in Texas during the past twenty years.

The advisability of such action is properly debatable. Three elements of the question are germane to the present discussion, namely, the relations of coyote elimination to livestock, to rodents, and to game. The first has been adequately covered in previous paragraphs; concerning the two other factors, two additional thoughts are presented, not by way of conclusion, but rather to stimulate further thought on a subject of vital importance.

In the coyote-free area of central Texas, the population of gray foxes is noticeably more dense than where coyotes are present (Taylor, 1947). Thus, predation on rodents has continued with but slight modification, despite elimination of predation on livestock and game. It seems doubtful that foxes will follow the coyote-wolf pattern of predator succession against grazing animals, although a few isolated instances of small predators' success against deer are known (Errington, 1946). Hence, even though predation may have slight relation to rodent populations, it is reassuring to know that this and other rodent-predator relationships are not necessarily disrupted by elimination of predation on ungulates.

Among grazing animals, it is desirable that predation upon domestic species be eliminated, but there are many places where a certain amount of predation upon big game is desirable from a game management standpoint. This is especially applicable to game ranges not visited by enough hunters to prevent harmful irruptions of deer or other species. Such situations would benefit from a moderate population of cougars and other large predators. Wildlife administrators recognize this, but can seldom practice it because of the presence of livestock.

There are many places where the incompatability between livestock and game is becoming so apparent that serious thought is being given to abandonment of the multiple use theory on lands clearly suited to specialized use. The anomaly of a sustained yield of both coyotes and livestock on identical range also should be apparent. A segregation of livestock and game areas would be especially desirable if a general policy of eliminating predation on livestock were adopted.

Predation could properly and profitably be eliminated on good quality livestock ranges and on game ranges subject to consistently heavy hunting pressure. Livestock could be logically excluded from the rougher, more heavily timbered and inaccessible areas subject to moderate or light hunting pressure and possessing high recreational, scenic, or aesthetic values. There are some rather serious obstacles to a universal practical application of this suggested segregation of land use. It is presented as an objective toward which land managers can aim in endeavoring to end an era of blundering and expensive experiments and begin an era of applied ecology on the western range.

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GESTATION PERIOD IN THE PORCUPINE, *ERETHIZON DORSATUM DORSATUM*

By Albert R. Shadle

Until recent years, the literature contained no exact information on the length of the gestation period in the Canadian porcupine, *Erethizon dorsatum dorsatum*. Various periods were suggested, but no actual dates of copulations and resultant births were known.

Seton (1909: 610), speaking of young porcupines, said that they "are of remarkable size, a guarantee of a long gestation." Struthers (1928) had evidence which at that time seemed to indicate beyond question a gestation period of sixteen weeks. Taylor (1935), from a study of the yellow-haired porcupine, believed that the gestation period would probably be between six months and seven and one-half months. Bailey (1936) said, "The mating season is said to be in September or October . . ., and the period of gestation about 9 months, but more careful field observations are necessary to verify the dates." Asdell (1946) quotes the figures given by Struthers for *E. d. dorsatum* and in the light of those figures questions the nine months in Bailey's figures. Shadle and Ploss (1945), commenting on a comparison of the condition of the spines at birth and on the July birth of one of their animals, stated that "The gestation period (of the porcupine) may be considerably more than 16 weeks."

From the dates of the births of our first three porcupines (copulation dates unknown), and the mating time of the first two porcupines which were observed in copulation in the laboratory, we felt sure that the gestation period of sixteen weeks was open to question and that the time must be considerably more than that, probably between six and seven months. In September, 1926, Struthers captured a female Canadian porcupine which he placed in his colony at Syracuse University. A male was placed with her on January 1, 1927, and nineteen days later, on January 20, copulation occurred. One hundred thirteen days after this copulation, on May 13, 1927, the female bore one young. The details of this mating were published by Struthers (1928) and there seemed no question that the gestation period was correct. Data gathered in our laboratory now suggest that there may be a different interpretation of these facts.

For several years a colony of eight to fourteen porcupines has been maintained in our Vivarium at Buffalo, New York. Among the problems studied have been the breeding and early phases of their life history. From 1940 to the present date, one female, "Maudie," has bred five times (1940, '42, '43, '44, '45) and produced three young (1941, '43, '44). The dates of the first three matings were unknown, and the last two matings, which were observed, produced no offspring. It is believed that this female has passed the age for fruitful mating because she was full grown when captured and has been in the Vivarium for the past nine years. These three young porcupines are believed to be the first *that have been bred and born in a laboratory.*

In 1944, November 18 and 26, respectively, "Maudie" (age unknown) and "Nightie" (thirty-one months old) were bred to the same male, "Old Dad," and

had no further contact with males (Shadle 1946). Of these two matings, as stated above, "Maudie" failed to produce an offspring, but on June 23, 1945, "Nightie" gave birth to a female, "Cuddles," weighing 504 grams. This first pregnancy of "Nightie" was a gestation period of 209 days.

This parturition appeared normal and the afterbirth was shed normally. Although the mother appeared to be perfectly healthy, she was found dead ten days later and the rearing of the young was done by hand. The success achieved in rearing this animal is borne out by her weight of eight pounds and four ounces at four months of age, and seventeen pounds at nine months. Such a size is not usually attained in the wild until they are probably three to four or more years of age.

From an unobserved laboratory breeding of "Maudie" and "Old Dad" in the fall of 1942, a female, "Prickles," was born on May 18, 1943. On November 4, 1946, at the age of three years and seven months, this female mated for the first time to "Johnie" (age five years and seven months) who was taken by Caesarian section by Donald Spencer (United States Fish and Wildlife Service) April, 1941, in northern New York. From this breeding of "Prickles" and "Johnie," a male weighing 413.9 grams was born on June 10, 1947, at the end of a 217-day gestation period, for a first pregnancy. The 217-day gestation period of "Prickles" closely approximates that of "Nightie" (209 days) and these two figures suggest that the figure of 113 days may not represent the complete duration of the gestation in the case of Struthers' animal.

Discussion.—It is well known that animals occasionally breed during a period of pregnancy. One of our female rabbits was observed to breed fourteen days after she had previously bred. At the end of the normal gestation period, counted from the first breeding, she kindled, thus demonstrating that she was pregnant at the time of her second breeding. This occurred several times later. During one pregnancy she was given an opportunity to mate on eight different days. She bred again each of the eight days during that pregnancy and kindled on the normal parturition day counted from the first breeding. This evidence from rodents has also been corroborated in domestic animals, showing that copulation during pregnancy is not uncommon.

It appears quite possible, as well as probable, that Struthers' female, taken in late September, may have come in heat early and bred before she was picked up in the wild. If true, she was already pregnant when he saw the pair copulate on January 20. If she bred first late in September, and her parturition date was May 13, that would give a gestation period of approximately seven and one-half months. Taylor (*op. cit.*) also came to this same conclusion, that the gestation period might be that long. The seven and one-half month gestation figure would be only a few days longer than the two gestations cited in this paper, and such an explanation would also account for the great discrepancy between Struthers' figure of 113 days and our 209 and 217 days. The 113 days then seem to be not a gestation period, but simply an interval of time from a copulation during a pregnancy to the end of the pregnancy and the date of parturition.

Figuring from the general fall mating time of the western porcupines, *Erethizon*

dorsatum epixanthum (Anderson and Rand, 1943), to the time when the young were usually born in the spring, and from evidences collected throughout the year, Taylor (*op. cit.*) said that they "show quite definitely a gestation period approximately seven months long." This estimate was probably based largely upon the evidence from the yellow-haired porcupine.

While it is highly desirable to obtain many more gestation figures on the North American porcupines, it seems reasonable, from the two figures available, that seven months approximates it very closely in the Canadian porcupine (*E. d. dorsatum*). When actual figures are available for the yellow-haired porcupine (*E. d. epixanthum*), they may correspond closely to those of the Canadian porcupine.

Summary.—Two young female Canadian porcupines were bred in November in the Animal Laboratory at the University of Buffalo and each had no further contact with males. In each animal it was a first pregnancy. These appear to be the first Canadian porcupines in which breeding, pregnancy, and births occurred under observation in the laboratory. Gestation was 209 days in one and 217 days in the other. These are the first actual figures where copulation dates and dates of birth are known. The gestation of 113 days (Struthers 1928) seems not to be a true gestation period, but simply the last 113 days of a gestation of an animal which bred again during pregnancy, and dropped her young at the end of the normal period counted from the first mating. Seven months appears to approximate closely the gestation period of Canadian porcupines.

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THE LAND MAMMALS OF NEW BRUNSWICK[1]

By R. F. Morris

Several catalogues of New Brunswick land mammals have been published in the past. The earliest to come to the attention of the writer was published in 1847 by Gesner. A second, by Adams, appeared in 1873. Both of these early papers contain much interesting information on the distribution and abundance of New Brunswick mammals in the last century. Descriptions of several species are also included by Adams. A catalogue of New Brunswick mammals was published by Chamberlain in 1884. In 1893 and 1894, J. A. Allen, aided by Mr. John Rowley, made two collecting expeditions to Trousers Lake and vicinity on the Tobique River. Allen's notes (1894a, 1894b) on these collections include several species of the smaller mammals which were missed by earlier observers. In 1896, Cox made some additions to Chamberlain's catalogue. Copeland and Church published a list of the mammals of Grand Manan Island, including those in the collection of Mr. John Moses, in 1906. All of these catalogues appeared in the last century and none of them is complete. Since the nomenclature for North American species of mammals has been extensively revised and since considerable changes in the distribution and relative abundance of several species have occurred in New Brunswick, a new list embracing the results of more recent observations and investigations may be of interest.

New Brunswick, with the Gaspe Peninsula on the north, the Nova Scotian Peninsula on the south, and the main continental area on the west, is in a peculiar geographic position. Forms of mammals described for the Gaspe are liable to extend into northwestern New Brunswick, which is quite similar in topography and forest conditions. Similarly, Nova Scotian forms may extend into southeastern New Brunswick, while in the west and central parts the main continental forms may occur. Thus it is possible that three subspecies of some of the more variable species, such as the red-backed vole, may be found in as small a political area as New Brunswick. It is apparent then that quite extensive collecting would be necessary in order to ascertain what forms occur and to delineate accurately their ranges. Such collecting has not yet been carried out in many parts of the Province. Accordingly, the present list is incomplete in this respect. It is hoped, however, that it may be of use in indicating where the greatest gaps occur in our present knowledge, and serve as a basis for future corrections and additions.

Several species, which have not been recorded in recent years and for which the records were apparently not substantiated by museum specimens, were included in some of the earlier lists. Other species have been taken near the borders of New Brunswick and may be expected to occur within the Province. In both such cases the writer has included the species in question, for the information of the collector, but has marked them with an asterisk. They should not

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be considered as a true part of the list because their occurrence in the Province is not definitely established.

In compiling the present list of species, many sources of information have been freely consulted. Lists prepared recently for adjacent provinces often make reference to forms extending into New Brunswick. Particularly useful in this regard is the list of Quebec mammals recently published by Anderson (1940); the lists of Nova Scotian mammals by Rand (1933) and Smith (1940); and the lists of Gaspe mammals by Goodwin (1924, 1929). Other papers dealing with Canadian species have been issued periodically by mammalogists of the National Museum of Canada. Advantage has also been taken of the collections made in New Brunswick for the National Museum of Canada by C. H. Young and R. M. Anderson in 1921; by W. E. Godfrey in 1939; and by W. H. Moore. In recent years the writer (1943) has made collections of forest insectivores and rodents in connection with a study of their value as predators on forest insects. These collections were deposited in the National Museum of Canada. The writer has also corresponded with various museums in the United States where some of the specimens of the early collectors were deposited.

The relative abundance of the different species is indicated only in general terms. However, the decisions regarding relative abundance, even in general terms, have not been made without difficulty in many cases. Some species, such as the snowshoe hare, are cyclic in behavior and may be scarce during some years and abundant in others. Other species are restricted in occurrence to a certain type of habitat. Although they may at times be abundant in their particular habitat, their relative abundance is undoubtedly influenced by the extent to which such habitat conditions occur in the Province. The lemming vole, for instance, must be considered rare in New Brunswick, since only a very few specimens have ever been recorded. It should be noted, however, that few investigators have troubled to collect small mammals in the cold sphagnum bogs that lemming voles appear to prefer. Abundance of nocturnal species is liable to be underestimated since they are not commonly observed during woods travel.

The relative abundance of the smaller mammals is based on the frequency with which they have been taken by the writer in traps, in different forest habitats, over a period of several years. For the larger mammals, it is based on the frequency with which they, or their signs, have been observed during several years of woods travel in all parts of New Brunswick. Advantage has also been taken of information provided by conversations with numerous woodsmen and trappers. With regard to game and fur-bearing mammals, the annual reports of the Department of Lands and Mines of New Brunswick have provided a useful indication of abundance from year to year.

Mention is also made of any significant changes that have been known to occur in the abundance of the various species of mammals within the period for which records are available. For more detailed information in this regard, the reader is referred to Squires (1946) who has consulted the early literature, relating to this part of Canada, as far back as the year 1610, and compared the various statements about mammal species and populations.

ACCOUNTS OF SPECIES

* **Parascalops breweri** (Bachman). Hairy-tailed mole.—This mole may possibly occur in the southwestern tip of New Brunswick. Chamberlain (1884) reported that he saw one specimen which was taken in Charlotte County in the last century. This record, although unsupported by specimens or by subsequent records, has been quite generally accepted.

Condylura cristata cristata (Linnaeus). Star-nosed mole.—All moles that have come to the attention of the writer have been of this species; it is common in suitable habitats throughout the Province.

* **Condylura cristata nigra** Smith. Star-nosed mole.—This subspecies was described from Nova Scotia (Smith, 1940), but it is not yet known whether it extends into southeastern New Brunswick.

Sorex cinereus acadicus Gilpin. Cinereous shrew.—The cinereous, or masked, shrew is the most common insectivore in New Brunswick, particularly in coniferous forests (Morris, 1943).

* **Sorex cinereus cinereus** Kerr. Cinereous shrew.—This is the main continental subspecies of the cinereous shrew and more specimens are necessary from western New Brunswick to ascertain whether it intergrades there with *S. c. acadicus*.

Sorex arcticus maritimensis Smith. Saddle-backed shrew.—The saddle-backed shrew is a rare species which is locally distributed in low, swampy areas. The only specimens on record for New Brunswick are two taken near Maugerville by Cox (1896) and one near Hampton by Mr. H. E. Hill. It is probable that these specimens are *S. a. maritimensis*, which was described from a larger series taken in Nova Scotia. More specimens are necessary, however, before the identity of the New Brunswick form, or forms, can be definitely established.

* **Sorex arcticus arcticus** Kerr. Saddle-backed shrew.—Due to insufficient collecting, it cannot be said to what extent this subspecies may occur in the Province (see *S. a. maritimensis*).

Sorex fumeus umbrosus Jackson. Smoky shrew.—This shrew is rare, but quite widely distributed. A few specimens have been taken by previous investigators in various parts of the Province, including Madawaska, Gloucester, Kings, and Sunbury counties. Fairly extensive trapping by the writer in recent years has not yielded a single specimen. It is apparently more common in Nova Scotia, however, in hemlock forests with mossy ground cover (Rand, 1933; Smith, 1940).

Sorex palustris gloveralleni Jackson. Water shrew.—There are a few specimens in the National Museum of Canada taken in Gloucester County by R. M. Anderson and C. H. Young, and one from Charlotte County by W. E. Godfrey. This species is one of the rarest of the shrews in New Brunswick, but it is sometimes taken near pools of open water in mossy, coniferous forests.

* **Sorex palustris albibarbis** (Cope). Water shrew.—The range of this water shrew is considered to extend into western New Brunswick (Jackson, 1928), but specimens have not yet been taken.

Microsorex hoyi thompsoni (Baird). Pigmy shrew.—The pigmy shrew occurs throughout New Brunswick. Although less plentiful than the cinereous shrew, the writer has found it to be moderately common at times in coniferous forests.

* **Microsorex hoyi intervectus** Jackson. Pigmy shrew.—It is thought that this subspecies, which occupies the Gaspe, may extend into northwestern New Brunswick, but definite records for that area are lacking.

Blarina brevicauda pallida Smith. Short-tailed shrew.—The short-tailed shrew is common in New Brunswick in hardwood stands where there is a ground cover of fallen leaves, but rather uncommon in most stands of spruce and fir.

Blarina brevicauda angusta Anderson. Short-tailed shrew.—Specimens of the short-tailed shrew from northwestern New Brunswick, including Madawaska County, were referred to this subspecies by Anderson (1940).

Blarina brevicauda talpoides (Gapper). Short-tailed shrew.—This shrew occurs in

western New Brunswick, but there has not been enough collecting to show where its range meets those of *B. b. pallida* and *B. b. angusta*.

Myotis lucifugus lucifugus (Le Conte). Little brown bat.—The little brown bat is common throughout New Brunswick and nearly all of the bats to come to the attention of the writer have been of this species.

Myotis keenii septentrionalis (Trouessart). Long-eared brown bat.—This bat is probably moderately common in New Brunswick, since it is common in both Nova Scotia (Rand, 1933) and the Gaspe (Goodwin, 1929). It has generally been overlooked because of its superficial resemblance to *Myotis lucifugus*, but it can be distinguished by its long ears which reach well past the tip of the nose when laid forward. There are a few specimens on record from Grand Manan and one from Gloucester County.

Lasionycteris noctivagans (Le Conte). Silver-haired bat.—This is a rare species in New Brunswick. There is a specimen in the Museum of Comparative Zoology that was collected on Kent Island, near Grand Manan, in 1938. There is also a specimen in the New Brunswick Museum taken in Saint John County in 1898. Anderson (1940) reported it to be abundant in southern Quebec, but it is not yet known in Nova Scotia (Smith, 1940).

* **Eptesicus fuscus fuscus** (Beauvois). Big brown bat.—The big brown bat probably occurs in New Brunswick, but there are no definite records. It is reported to be common in southern Quebec (Anderson, 1940) and has been taken at Eastport, Maine. Its range is generally considered to include New Brunswick and Nova Scotia (G. M. Allen, 1933), although specimens are lacking. Like the little brown bat, it frequents houses and barns where it hibernates in colonies.

Lasiurus borealis borealis (Müller). Red bat.—The red bat was listed by Chamberlain (1884) as a rare species in New Brunswick. Copeland and Church (1906) record one specimen in the collection of John Moses of Grand Manan that was taken about 1900. It is reported to be common in southern Quebec, but not often seen because it frequents trees rather than houses (Anderson, 1940).

Lasiurus cinereus (Beauvois). Hoary bat.—This bat was listed by both Adams (1873) and Chamberlain (1884) as uncommon in New Brunswick. Copeland and Church (1906) recorded a single specimen in the collection of John Moses, taken about the same time as the red bat. One specimen has been taken at Halifax, Nova Scotia (Smith, 1940). This large bat is another migratory species which frequents the forests.

Euarctos americanus americanus (Pallas). Black bear.—The bear is common throughout New Brunswick. A Provincial bounty of $10.00 a head is probably reducing its numbers, at least in the settled regions. The annual kill in recent years is generally between 700 and 1500.

Procyon lotor lotor (Linnaeus). Raccoon.—The raccoon is moderately common along the coast and the settled parts of the larger rivers, at least in the southern half of the Province, but rarely found in the densely forested regions of the interior and northern part. New Brunswick is in the northern limits of the range of this species. Goodwin (1924) reported that one specimen was trapped in the Gaspe in 1923, where it was unknown to the inhabitants. Its preferred habitat usually includes open fields along the edge of hardwood stands and near water. Because of its nocturnal feeding habits it is not often seen.

Rand (1943a) gave interesting evidence to show that in Nova Scotia the raccoon occurred in early times, then disappeared between 1606 and 1870. It was returning in 1870 and since then has increased sufficiently in numbers to be considered as common in some parts. There is also some indication that the raccoon may have become more common in New Brunswick since the last century. Squires (1946) noted that it was never mentioned by the early French writers and so must have been very rare or absent at that time. The first references to it in this Province appeared in 1825 and 1832. Adams listed it as very rare in 1873, and in 1884 Chamberlain listed it as very rare, except along the Bay of Fundy Coast. J. A. Allen (1894b) reported that he had evidence of its occasional occurrence at Fredericton, but not in the Trousers Lake region. The number of pelts on which royalties are paid annually has increased in New Brunswick to over 2000 in recent years.

Martes americana americana (Turton). Marten.—Although formerly common, the marten is now rare and restricted to the more remote areas. At one time it was one of the most abundant fur-bearing species in New Brunswick. All of the lists for the last century reported it to be abundant throughout the Province, although Adams suspected that it was beginning to decline in numbers in 1873. He described this species in some detail and thought that specimens from hardwood forests were lighter in color than those from pine forests. It has become so scarce in recent years that, for the period 1939 to 1944, royalties were paid on an average of only seventy-five pelts annually. It has had a similar history in adjacent provinces, and Anderson (1940) believed that this decline is due to over-trapping, since the fur is very valuable. A closed trapping season was initiated in New Brunswick in 1945. It is to be hoped that this has not been effected too late to prevent extermination of this species.

Martes pennanti pennanti (Erxleben). Fisher.—The fisher is rare, but still to be found in the more remote forests of the center and north. It was formerly more common, but apparently never very plentiful within historical times. The fisher is probably the rarest and most valuable fur-bearer in Canada and this has led to its extermination in many of the more settled parts. The reports on New Brunswick mammals for the last century suggest that it was then more widespread, but was nowhere very plentiful. It is now considered to be extinct in Nova Scotia (Smith, 1940) where about 200 pelts per year were taken near the middle of the last century. For the period 1939 to 1944, royalties were paid on an average of thirty-two pelts annually in New Brunswick. Closed trapping season was initiated in 1945 for this species.

Mustela erminea richardsonii Bonaparte. Short-tailed weasel.—This is the common weasel of New Brunswick and royalties are generally paid on 10,000 to 16,000 pelts annually. It fluctuates in numbers, however, probably depending upon the food supply.

Mustela frenata occisor (Bangs). Long-tailed weasel.—Adams (1873) described two species of ermine, or weasels, from New Brunswick and his measurements indicate that one was *M. erminea* and the other *M. frenata*. Authentic specimens of the latter were lacking, however, until 1946 when one was collected near Fredericton by N. R. Brown. This species is much less common than *M. erminea*.

* **Mustela rixosa allegheniensis** (Rhoads). Least weasel.—The least weasel may possibly occur in parts of New Brunswick, but it is not yet recorded. This is a rare species that has been recorded locally in parts of Quebec and in some of the northeastern States. There is some evidence of its presence in Nova Scotia.

Mustela vison vison Schreber. Mink.—This fur-bearer is moderately common in suitable habitats. Royalties are paid on about 2000 pelts annually.

Gulo luscus luscus (Linnaeus). Wolverine.—This species was formerly present, but never very common. New Brunswick was at one time in the southern limits of its range. It is apparently an animal that will not tolerate civilization. Squires (1946) quoted records showing that eight pelts were exported from Saint John between 1764 and 1774. Chamberlain (1884) reported: "Some 30 years ago it was occasionally met with, but no recent instance of its occurrence is known."

Lutra canadensis canadensis (Schreber). River otter.—The otter is now generally rare and apparently limited in distribution to wilderness rivers. The lists for the last century reported it to be moderately common in favorable localities. None has been seen by the writer, but, for the period 1939 to 1944, royalties were paid on an average of seventy-eight pelts annually. A closed trapping season on this fur-bearer was initiated in 1945.

Mephitis mephitis mephitis (Schreber). Striped skunk.—The skunk is common throughout New Brunswick, particularly in the vicinity of cleared land. It is possible that this species has increased in New Brunswick since the last century, but definite evidence is not available. In 1873, Adams reported that it was increasing. Gilpin (1870) believed that it entered Nova Scotia in comparatively recent years and that it was not known there before 1850.

Vulpes fulva rubricosa Bangs. Red fox.—This species is common throughout the Province. The cross fox, a color phase of this species, is also occasionally taken. During the past few years some 4000 foxes have been trapped annually (Ritchie, 1944).

* **Vulpes fulva fulva** (Desmarest). Red fox.—This form occurs in southern Quebec and the eastern States and possibly enters western New Brunswick.

Canis lupus lycaon Schreber. Timber wolf.—The wolf is now extinct, but was formerly common, at least during the first part of the Nineteenth Century. Squires found that the only mention of this species by early French writers was by LeClerq in 1691 and that between 1764 and 1774 only two Nova Scotia wolves were included in the list of furs exported from Saint John. He concluded that either it was more numerous than these records implied or that it increased rapidly because a New Brunswick bounty was initiated in 1792. The latter possibility is favored by Gesner's (1847) statement that the wolf first appeared in New Brunswick in 1818, extending its range far beyond former limits. Gesner and other writers of the time reported it to be numerous and destructive in the first half of the Nineteenth Century. Ganong (1908) said the last bounty was paid for three animals killed in 1862, but quoted evidence to show that the species was present in the more remote parts of the Province for a number of years later. In 1873, Adams stated that it was then found in the northern parts only and J. A. Allen (1894a) said that it had been extinct for some years.

* **Felis concolor couguar** Kerr. Cougar.—The cougar, or panther, probably occurred very sparingly in earlier times. In 1847, Gesner listed the cougar as very rare; Adams listed it as "doubtful" in 1873; and in 1884, Chamberlain said that no recent instances of its occurrence were known. In 1903, Ganong summed up the available records and concluded that there was no authentic evidence of either the present or former occurrence of the cougar within the limits of New Brunswick. G. M. Allen (1942) believed that it disappeared from eastern United States about 1840, where it formerly occurred sparingly in New England and the southern half of Maine. Its original range is thought to have coincided with that of the white-tailed deer, which was its chief prey. It may be of interest to mention that reports of the recent occurrence of the cougar have been made in both Maine (G. M. Allen, 1942) and New Brunswick (Wright, 1941). To date, however, these reports have not been substantiated by specimens.

Lynx canadensis canadensis Kerr. Lynx.—The lynx was formerly common, but is now very rare and restricted to the more remote parts of the Province. Levinge (1846) listed both the lynx and the bobcat as common in New Brunswick and described accurately the difference between the two species. The other lists for the last century also indicate that the lynx was then common, which was also the case within the memory of the older woodsmen. Within the present century, however, it has greatly decreased in numbers and is now on the verge of extirpation. Ritchie (1944) reported that one specimen was taken in 1943, the only one he knew of in some fifteen years. It has had a similar fate in Nova Scotia. Smith (1940) believed that it is now extinct on the mainland of that Province, but may still be found on Cape Breton Island.

Lynx rufus rufus (Schreber). Bobcat.—The bobcat, or wildcat, is moderately common throughout the Province. Royalties are collected on 500 to 1000 pelts annually. From a summary of the earlier literature, Squires (1946) concluded: "It seems probable that during the last hundred years the positions of the two lynxes in our fauna have been reversed; that the Canada lynx was formerly so much the more common that it was the only one that came to the attention of many of the writers, whereas in late years it has become almost extinct in the Province while the wildcat is now abundant."

Lynx gigas Bangs. Nova Scotia bobcat.—This larger bobcat was described from Nova Scotia and is reported to occupy parts of eastern New Brunswick. Some writers are not satisfied as to the specific identity of *L. gigas* and believe it is more liable to be a subspecies of *L. rufus* (Smith, 1940). More specimens are required before its taxonomic position or range in New Brunswick can be determined.

Marmota monax canadensis (Erxleben). Woodchuck.—The woodchuck, or groundhog, is common, particularly near settlements.

* **Marmota monax johnsoni** Anderson. Woodchuck.—The range of this subspecies is thought to extend into northwestern New Brunswick, but specimens are not yet available from that area.

Tamias striatus lysteri (Richardson). Eastern chipmunk.—The chipmunk is moderately common in suitable habitats. It is usually seen in small hardwood areas, particularly near cleared land.

Tamiasciurus hudsonicus gymnicus (Bangs). Red squirrel.—This squirrel is abundant throughout New Brunswick.

Sciurus carolinensis leucotis (Gapper). Gray squirrel.—The gray squirrel is locally distributed in or near towns in the southern part of New Brunswick. It has a similar type of distribution in adjacent parts of eastern Canada, and Rand (1933) believed that in Nova Scotia it became established from escaped introduced animals. In New Brunswick, Squires (1946) found that the first reference to this species in the early literature occurred in 1832, and in the latter part of the last century both Adams and Chamberlain reported it to be present in the southwestern part of the Province. The black color phase occurs rarely. The writer has seen the gray squirrel as far north as Woodstock and from a summary of other recent reports Squires (*ibid.*) believed that its present northeastern limit may be represented by a line from Woodstock through Scotch Lake, Stanley, Grand Lake, Gagetown, Brown's Flats, and West Saint John.

Glaucomys sabrinus macrotis (Mearns). Northern flying squirrel.—The flying squirrel is perhaps moderately common in New Brunswick, but is not frequently seen or trapped because of its nocturnal and arboreal habits.

* **Glaucomys sabrinus gouldi** Anderson. Northern flying squirrel.—It is not yet known whether this subspecies extends into southeastern New Brunswick.

Castor canadensis acadicus Bailey and Doutt. Beaver.—Originally numerous, the beaver was at one time in danger of extinction from over-trapping and the lists for the latter part of the last century indicate that at that time it was already becoming scarce in accessible areas. In recent years, however, a closed trapping season and a program of restocking trapped-out areas have so favored the beaver that controlled trapping was again permitted in 1944 and 1945. It was estimated that through these measures the population increased from a few hundred in 1933 to some 20,000 in 1944 (Ritchie, 1944).

Peromyscus maniculatus abietorum (Bangs). Deer mouse.—The deer mouse is common in all forest types throughout New Brunswick. Of the Cricetidae, it is second in abundance only to the red-backed vole.

Peromyscus maniculatus argentatus Copeland and Church. Deer mouse.—This subspecies of the deer mouse is restricted to the Island of Grand Manan.

* **Peromyscus leucopus caudatus** Smith. White-footed mouse.—This is the common species of *Peromyscus* occurring throughout the settled areas of western Nova Scotia, where it prefers grassy fields, marshes, and small woodlots. No specimens from New Brunswick have as yet been referred to *leucopus*, however.

Synaptomys cooperi cooperi Baird. Lemming vole.—A few specimens have been taken by others from widely separated parts of the Province (J. A. Allen, 1894b; Anderson and Rand, 1943), but none has been secured by the writer. Lemming voles are notably cyclic in abundance, however, and it is not improbable that this species may at times be fairly common in its preferred habitats.

Synaptomys borealis sphagnicola (Preble). Lemming vole.—This species is very rare and locally distributed. The only specimen ever recorded from New Brunswick was taken by Dr. Anderson in 1921 near the Miramichi road in Gloucester County. The only specimens taken elsewhere are the type specimen from New Hampshire; two specimens from Mount Katahdin, Maine; four from St. Rose, Quebec; and one from the Gaspe (Anderson, 1940).

Clethrionomys gapperi ochraceus (Miller). Red-backed vole.—This vole, or short-tailed mouse, is common and widely distributed in all of the main forest types. Observations by the writer during the past five years indicate that this species is the most abundant of the Cricetidae in New Brunswick, particularly in coniferous types. J. A. Allen (1894a) found

the same to be true in the last century. Specimens lacking the typical red color on the back are not uncommon. Specimens of this type, which may vary from gray to almost black, were first discovered by Allen on his expedition to Trousers Lake in 1894 and were described as a new species, *Evotomys* (*Clethrionomys*) *fuscodorsalis*. This was subsequently recognized to be only a melanistic phase of *C. gapperi* and is now often referred to as the "fuscodorsalis" color phase. In most parts of New Brunswick, "fuscodorsalis" specimens occur in the ratio of about one or two per hundred specimens of the typical red phase.

Clethrionomys gapperi gaspeanus Anderson. Red-backed vole.—The Gaspe form extends into Madawaska and parts of Restigouche Counties in northwestern New Brunswick.

Clethrionomys gapperi rufescens Smith. Red-backed vole. The Nova Scotia subspecies intergrades with *C. g. ochraceus* in southern New Brunswick (Smith, 1940).

Microtus pennsylvanicus pennsylvanicus (Ord). Meadow vole.—This is a common species in suitable habitats. In the Gaspe, meadow voles are sometimes taken in coniferous forests where the deep moss affords them excellent cover. In New Brunswick, however, the moss layer in most stands is not sufficiently deep for this purpose and the meadow vole, although common in damp grass or sedge lands, is rarely taken in the forest. This species may fluctuate considerably in abundance.

Microtus pennsylvanicus acadicus Bangs. Meadow vole.—This form occupies the Island of Grand Manan in New Brunswick and presumably parts of the southern mainland (Rand, 1943b).

Microtus chrotorrhinus chrotorrhinus (Miller). Rock vole.—This vole is rare and locally distributed. Four specimens were taken on the Tobique by J. A. Allen in 1894 and one specimen near the head of Green River, Restigouche County, by the writer and F. C. Hirtle in 1945. It has not been recorded to date in southern New Brunswick or in Nova Scotia.

Ondatra zibethica zibethica (Linnaeus). Muskrat.—The muskrat is common in all suitable habitats throughout New Brunswick. Royalties are paid on some 20,000 pelts annually. To prevent over-trapping, a policy of declaring closed season every fifth year has recently been announced by the Province.

Mus musculus domesticus Rutty. House mouse.—This mouse is common in all settled parts, both in buildings and in nearby fields. In Nova Scotia, Smith (1940) reported taking specimens from *Microtus* runways in midwinter, so it appears that the house mouse may be capable of establishing itself along with native species independent of buildings. It apparently became introduced in the early days of settlement, since the earliest lists for the last century record it as already abundant.

Rattus norvegicus (Berkenhout). Norway rat.—The rat is a common pest in all settled parts, and even in remote woods camps. Its history in this region has probably been similar to that of the house mouse.

Rattus rattus rattus (Linnaeus). Black rat.—Listed by Gesner in 1847, and, in 1884, by Chamberlain who stated that a few specimens were taken at St. Stephen by Mr. G. A. Boardman. No recent instances of its occurrence in New Brunswick are known. The black rat was formerly introduced over a wide territory on this Continent, but has now been largely driven out by the Norway rat. It is possible, however, that it may occasionally be introduced near the seaports.

Zapus hudsonius canadensis (Davies). Meadow jumping mouse.—The meadow jumping mouse is only moderately common in New Brunswick. It prefers open grassland, and wild meadows, where it may locally be common at times. No specimens have been taken by the writer in forested land. *Z. h. canadensis* occurs in the western part of New Brunswick.

Zapus hudsonius acadicus (Dawson). Meadow jumping mouse.—This subspecies occurs in Nova Scotia and the eastern part of New Brunswick, but sufficient specimens are not available to show where its range meets that of the preceding subspecies.

Napaeozapus insignis insignis (Miller). Woodland jumping mouse.—This species is generally uncommon, but like the foregoing species it may at times be fairly common in restricted localities. It is more widely distributed than *Zapus* and, in addition to sites occupied by that species, is also found in many forest types. In New Brunswick, the writer

has taken it in coniferous forests near grass-bordered brooks, in sphagnum bogs, and in young plantations where there was a ground cover of grass.

Erethizon dorsatum dorsatum (Linnaeus). Porcupine.—The porcupine is common and widely distributed in the forested parts of the Province. A bounty of fifty cents each, which has been in effect in New Brunswick since 1942, has apparently resulted in a reduction in the numbers of porcupines, at least near settlements and lumber camps. In 1943, this bounty was collected on 68,549 snouts; in 1945, the number was reduced to 36,824. Reeks (1942) presented some interesting data on its population and habits in the Maritimes.

Lepus americanus struthopus Bangs. Snowshoe hare.—The hare, locally called 'rabbit,' is cyclic in population behaviour, but generally common.

Odocoileus virginianus borealis Miller. White-tailed deer.—The deer is now the principal game animal of the Province. The annual kill is ordinarily between 10,000 and 15,000. The writers of the last century believed that the deer was a comparative newcomer to New Brunswick. Gesner was of the opinion that it first appeared in the Province in 1818 and by 1848 had become common in Charlotte County, particularly in the valley of the Magaguadavic. In Adam's time (1873) it was still quite localized, but was expanding its range to the northeast. In 1884, Chamberlain reported that it was generally uncommon, though increasing, and had recently spread into York County and as far north as Carleton and Victoria counties. In 1894, J. A. Allen (1894a) did not find it in the Trousers Lake area, but knew of its occurrence farther down the Tobique River near cleared land. Since that year, it has occupied the rest of the Province and has considerably increased in numbers. In 1896, fourteen specimens were introduced from New Brunswick into Nova Scotia and it has shown a similar increase in that Province. Squires, however, doubted that deer were not present in New Brunswick before the last century and quoted several references to them, as well as to moose and caribou, by French writers of the Seventeenth Century. Among the skins shipped from Saint John between 1764 and 1774 were eighty-five deer skins. It would appear then that deer, although formerly present, became exterminated or very scarce near the beginning of the last century. This is substantiated by Smith (1940), whose discovery of its bones in Indian shell mounds in Nova Scotia indicates that it existed there at sometime prior to its re-introduction from New Brunswick. If the history of deer in New Brunswick is compared with that of the wolf, it will be seen that the two species have varied inversely in numbers and distribution, probably because the former is easy prey for the latter when yarded in deep snow. This presumably explains the disappearance of deer at the first of the last century when the wolf was plentiful.

Alces americana americana (Clinton). Moose.—The moose is still moderately common in some regions, but was formerly more common and more generally distributed. Squires has traced the history of the moose, showing that it was abundant in the Seventeenth and Eighteenth centuries, but became so scarce in the last century that it was protected in some parts of the Province by closed hunting seasons. Some of the writers in the early part of the last century even believed that it had become extinct. Apparently this was largely due to over-shooting. It increased, however, and remained plentiful until 1930, the annual kill averaging over 1000. Its numbers then declined rapidly and, although there has been no open hunting season on this species since 1936, it has not increased to its former numbers in the Province.

Rangifer caribou caribou (Gmelin). Caribou.—The caribou, formerly common throughout the Province, is no longer found there. In 1847, Gesner reported the caribou as common. In 1873, Adams reported that it was confined to the more heavily forested regions and apparently decreasing. J. A. Allen (1894a) reported that it was still common, but found only as far south as Woodstock. Since that date it continued to retreat to the north and finally disappeared from the Province about 1927. The reasons for its disappearance are not clear, but G. M. Allen (1942) assumed that the ease with which it could be shot and its apparent aversion to settlements and forest operations have been contributing factors. Anderson (1940) believed that the destruction of its favourite food, the Reindeer Moss, by fires had been an additional factor.

DISCUSSION

An attempt has been made in this list to include all of the recent land mammals known to occur in New Brunswick or to have occurred there within the period of time for which records are available. Mention has also been made of all the additional species that are liable to occur there, but for which authentic specimens are not yet available. It has been seen that considerable gaps occur in our knowledge of New Brunswick mammals, particularly in the case of some of the smaller and less commonly known species such as the bats and the shrews.

This list includes fifty species for which definite records are available; three of these species are now extinct in New Brunswick. An additional five species have been listed as probably occurring within the Province, but not yet definitely recorded. One of these, the panther, is extinct in this region. In terms of subspecies or races, a total of fifty-seven forms is known to occur, of which the same three are extinct, and an additional eight forms of the known species may possibly occur.

A number of changes have occurred during the last 100 years both in the abundance and the distribution of several species. These have resulted in a net loss in the variety of our fauna. There is a natural tendency to attribute these changes to the effects of man on the natural environment, particularly in land clearing and forest operations, or to his direct effect on the animal population by shooting and trapping. In many cases this provides a logical explanation, especially in the case of species whose disappearance has coincided with the settlement of the land. It should be borne in mind, however, that there is evidence that such changes occurred before the advent of the white man in this region and that bones from Indian refuse heaps indicate that some species were present several centuries ago, species which we consider as fairly recent additions to our fauna.

No definite changes can be recognized in the case of most of the smaller mammals. Several new species have been added to the records, but they represent mostly rare species which were probably missed by the earlier observers.

Many of our larger carnivores have disappeared, including the cougar, the wolf, and the wolverine, and the lynx appears to be on the verge of extinction. Since these species were all inimical to the interests of the early settlers, it is probable that their disappearance has been aided by their destruction whenever encountered, encouraged by legal bounties. The bear, however, and the bobcat have held their own, despite similar bounties.

The more valuable fur-bearers, such as the marten, the fisher, and the otter, have been greatly reduced in numbers and have retreated to the more remote parts of the Province. This appears to be a result of over-trapping and it is gratifying to learn that these species are now protected. The beaver was in a similar position at one time, but its situation has been greatly improved by careful management practice. Two of the less valuable fur-bearers, the raccoon and the skunk, are species which prefer the edge of cleared land and there is some evidence that they have increased since the last century.

As to the large game animals, the caribou has been entirely replaced by the

white-tailed deer as the game animal of the Province. The situation with regard to the moose, formerly an important game species, is still doubtful.

ACKNOWLEDGMENTS

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NOTES ON THE HAITIAN HUTIA, *PLAGIODONTIA*, AND EXTINCT RELATED GENERA

By G. H. H. Tate

The New York Zoological Society has just received from Haiti two living specimens of mammals, seemingly identical to Oviedo's "Hutia," named *Plagiodontia hylaeum* Miller (1927).

Flower (1929: 229) indicated that a live specimen had previously existed in the London zoo about ninety years ago. Thereafter, *Plagiodontia* was believed to be extinct until Miller (1916–30) indicated in a series of papers that at least one species of the genus was still to be found living. Miller recognized three species, *aedium* Cuvier, *spelaeum* Miller (extinct), and *hylaeum* Miller. Whether *P. aedium* is extinct has yet to be demonstrated.

At the invitation of Mr. Lee Crandall, I examined the specimens. One was dark brown, slightly paler beneath, with tail and feet pigmented fuscous; the other, light orange brown, partly albinistic, with pink eyes and unpigmented hands, feet, and tail. The ears were quite short (about 15 mm.); the tails were proportionately short as in *Geocapromys*. Both specimens were males.

The normally colored animal was caught with gloved hands for closer examination and rough measuring. It squeaked and resisted strongly and bit at the gloves. When the head was held, the mouth was opened. A corner of the mouth could be drawn back slightly to reveal the oblique pattern of the enamel folds of the anterior upper molars, which distinguish *Plagiodontia* from the Capromyidae. Our rough measurements, which fit the smaller specimens of Miller's (1927) table, include: head and body, ± 310 mm.; tail, ± 140; hind foot, *s.u.*, 63, *c.u.*, 70 mm.

The closest locality so far obtained for the new specimens is "mountains of southern Haiti." The altitude is still unknown.

The animals climb readily. When the darker one was returned to the cage the albinistic specimen had climbed the wire side of the cage to the top. The animals seem to be nocturnal; by day they crouched close together motionless. They readily ate fresh leaves, nuts, and fruit, but only a little of the grain provided.

The use of the name Hutia for *Plagiodontia* seems to be justified. Miller has shown that the Hutia of Oviedo (1547) in all likelihood was *Plagiodontia* and, in

consequence, its employment by Desmarest (1822) for *Capromys* was slightly erroneous. Long usage, however, has established Desmarest's name and Mr Crandall now proposes to dub *Plagiodontia* the "Haitian Hutia."

On the basis of two specimens of *Plagiodontia* taken to France by Alexander Ricord, Cuvier (1836) gave the length of head and body as one foot (French), of the tail as five inches. These dimensions were followed by a detailed description of the skin, teeth, and skull (1836: 350–352). The pale color of the fur in Cuvier's colored plate and the touches of pink introduced into the hands, feet, and tail suggest that a measure of albinism was present in the specimen depicted. However, the artist made the eye black. Gervais (1854) figured a skull of *Plagiodontia*—apparently not the same skull as that figured earlier by Cuvier (*fide* Miller).

Finding discrepancies between the sizes of *aedium* and the recent specimens sent him by Dr. Abbot, Miller (1927) decided to describe the latter as new (*hylaeum*), at the same time referring skull fragments of a larger species to *aedium* Cuvier. It is thus clear that not only *hylaeum*, but *aedium* also may still live in Haiti. The two animals now at the zoo are rather small and seem better referable to *hylaeum*.

It is well to point out that not many centuries ago the Greater Antilles was the home of a rather specialized group of Hystricoid rodents (now subfossil) having the molar laminae strongly sloping. This group is typified by *Plagiodontia*, the only living genus, which Ellerman (1940) raised to the rank of a subfamily of the Echimyidae–the Plagiodontiinae. Simpson (1945) placed *Plagiodontia* in the Capromyidae and *Isolobodon* in the Echimyidae. He omitted *Quemisia* (see beyond).

Isolobodon, which was described from Porto Rico by J. A. Allen (1916), stands quite close to *Plagiodontia* and the two may even prove to be congeneric; the slope of the laminae of the molars is nearly similar to that in *Plagiodontia*, differing only in the degree of inclination to the toothrow. The living animals probably presented a very similar appearance to species of *Plagiodontia*.

Miller (1922) recorded *Isolobodon* from Haiti under the generic name *Ithydontia* (type, *levir*), but later (1929) placed *Ithydontia* in the synonymy of *Isolobodon*. Still other generic offshoots of this subfamily were *Aphaetreus* Miller; *Quemisia* Miller, and *Elasmodontomys* Anthony. All had sloping molar enamel plates. *Quemisia* and *Elasmodontomys* were as large as small hounds.

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GENERAL NOTES

A COLOR PATTERN ABERRATION IN *PIPISTRELLUS SUBFLAVUS SUBFLAVUS*

An adult female pipistrelle (*Pipistrellus subflavus subflavus*) of unusual color pattern was among several bats of this species collected February 10, 1947, by Floyd Potter in Cascade Cavern, 8.4 miles southeast of Boerne, Kendall County, Texas. This aberrant individual is white in appearance over most of the dorsal and ventral surfaces of the body exclusive of the head and the extreme posterior part of the body. The wings, feet, tail, interfemoral membrane, rump, and ears are normal brown.

The change from normal color pattern is limited to the body of the animal. The maximum loss of pigment centers in the mid-dorsal area. The face, chin, ear pinnae, and tragi are brown, and show no deviation from normal coloration. Posterior to the anterior insertion of the pinnae, the dorsal body hairs show a general paling in a band about ten millimeters wide (measured in dry skin). The hairs in this band are pale slaty gray at their bases and pale brown at their distal ends. The paleness of pigmentation increases posteriorly, and this band of pale hairs merges gradually into an area of completely white pelage. This white area is about sixteen millimeters in antero-posterior width and comprises approximately the central one-third of the dorsal surface. Lateral to this, the hairs are distally white and proximally pale slaty gray. Posterior to the central area of completely white hairs there is a gradual increase in intensity of pigmentation, with a progression through hairs that are distally white and proximally pale gray to hairs that are pigmented throughout. The rump hairs, in a band about seven millimeters wide, are normal dark brown in color.

On the ventral body surface, most of the hairs are pale slaty gray at their bases and white at their distal ends. An indistinctly defined area in the mid-thoracic region has the hairs white throughout their length. The hairs of the chin are normal in color; they grade posteriorly into the white-tipped, pale-based hairs of the ventral body surface. At the posterior end of the body, the hairs immediately bordering the interfemoral membrane are normal or nearly normal in coloration.

Microscopically, the hairs from pale areas of the aberrant individual, by comparison with the hairs of a normal pipistrelle, show varying degrees of reduction in the intensity of color in the pigment granules. In the most extreme cases (i.e., completely white hairs) no pigment granules can be detected. In others, the granules are varying shades of pale sepia rather than the dark sepia of normal hairs. The mutation, or mutations, responsible for the pattern of this aberrant individual affects the intensity of the pigment in bilaterally

symmetrical areas of the pelage. Bilateral reduction in the intensity of pigmentation occurs commonly in many rodents. Certain of these rodents, *Perognathus apache gypsi* and *Peromyscus polionotus leucocephalus*, have the pigmented area much reduced. In the latter species, at least, multiple genes are involved in the reduction of the size of the pigmented area. It is of interest that, in the above-mentioned rodents, whiteness of pelage centers in the mid-ventral region with an increase in intensity of pigmentation toward the dorsal surface. In this mutant bat, whiteness of pelage centers in both the mid-dorsal and mid-ventral areas with an increase in intensity of pigment toward the anterior and posterior ends of the animal and with a lesser increase toward the lateral surfaces.

This aberrant bat, with its white body and dark-brown wings, is strikingly conspicuous by comparison with normally-colored individuals of the same species. Natural selection should, therefore, tend to eliminate such conspicuous individuals from the population of this species.—W. Frank Blair, *Department of Zoology, University of Texas, Austin 12, Texas.* *Received October 3, 1947.*

A BAT (*PIPISTRELLUS*) RECORD FROM HONDURAS

While checking a number of unidentified alcoholic specimens in the collection of the Division of Mammals, University of Michigan Museum of Zoology, I discovered three small bats, collected on the Jilamo Farm, Dakota Division, Tela District, of the United Fruit Company, in Honduras. They were taken May 23, 1924. These specimens proved to be of the genus *Pipistrellus*. All were adult females, each with two well-developed embryos.

To the best of my knowledge, this constitutes the most southern record of occurrence for this genus in the Western Hemisphere. The following description and comparisons are given to make the data generally available.

Even after nearly twenty-five years in alcohol, the color of these specimens is still much darker than that of any *Pipistrellus* available for comparison. The arrangement of color bands on the hairs is similar to what is described for *Pipistrellus veraecrucis* Ward. The distribution of fur on the body and membranes is apparently the same as in *Pipistrellus subflavus* F. Cuvier. The external measurements of catalogue numbers 55863, 55864, and 55865, respectively, in millimeters, are: ear from notch, 12, 12, 11; tragus (outer border), 4.8, 4.6, 4.7; forearm, 33, 31, 33; thumb, 6, 6, 6; tibia, 14, 14, 14; foot, 9, 8, 8. Total length and tail length could not be taken without chance of gross inaccuracy.

The skulls were removed from the specimens and cleaned. In comparison with *P. subflavus* from Georgia and Oklahoma, the crania are smaller and the rostrum is shorter and relatively broader. The frontal bulges are less prominent, and the brain case is more evenly rounded. The temporal line is more prominent than in *P. subflavus*. The tooth rows tend to be more convergent posteriorly. The teeth correspond almost exactly with those of *P. subflavus*, but differ from those of *P. veraecrucis* in having the lower incisors spaced unequally and the basal cusps present on both the anterior and posterior borders of the lower canines. The following skull measurements were taken (catalogue numbers 55863–5, respectively, in millimeters): greatest length, 12.3, 12.4, 12.9; condylobasal length, 10.8, 10.6, 11.2; greatest width of brain case, 6.5, 6.4, 6.3; height of brain case, including bullae, 5.7, 5.8, 5.6; greatest zygomatic width,—, 7.7, 7.4; interorbital constriction, 3.5, 3.4, 3.1; length of bony palate, 4.4, 4.3, 4.3; length of upper tooth row, excluding incisors, 4.0, 3.9, 4.2; distance from labial border of right M^2 to labial border of left M^2, 4.8, 5.0, 4.9; distance from posterior border of palatal shelf to lip of foramen magnum, 4.5, 4.4, 4.6; length of bullae, 2.4, 2.5, 2.4.

These specimens do not correspond well with any known form of *Pipistrellus* from Mexico or Central America. This is especially true in regard to *Pipistrellus cinnamomeus* Miller and *Pipistrellus hesperus australis* Miller. Under the circumstances, it seems best to withhold specific identification until more specimens are available. The similarity of these individuals to *P. subflavus* is so great that only the distance of the locality from the known geographic range of that species prevents me from referring them to it, as a new race. On the basis of size and darkness of pelage, they might be assigned to *P. veraecrucis*, but in

view of the fact that the teeth do not correspond to the type description of this form, it does not seem advisable. When more material becomes available, *P. veraecrucis* may prove to be a race connecting the typical subspecies of *P. subflavus* with an undescribed race in Honduras.

The presence of embryos in these specimens contributes to the knowledge of reproductive activity of bats in Central America. All the embryos are quite large and well developed. The two taken from female number 55863 measure 32 mm. each in total length, and have wingspreads of 58 mm. and 61 mm. The facial vibrissae are well developed and hair is beginning to show through the skin of the head. As the date of capture was May 23, 1924, no doubt parturition would have occurred before June 1.

I wish to thank Dr. W. H. Burt for permission to report these specimens.—GEORGE C. RINKER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.* *Received January 26, 1948.*

PIPISTRELLUS CINNAMOMEUS REDISCOVERED

On May 4, 1900, E. W. Nelson and E. A. Goldman captured a bat on the edge of the town of Montecristo, state of Tabasco, Mexico. This was subsequently named *Pipistrellus cinnamomeum* (G. S. Miller, Proc. Acad. Nat. Sci., Philadelphia, May [September 3], 1902: 390). Since no additional specimens seem to have been reported as taken in the ensuing years, the capture of three bats of this species in 1946 seems worthy of record.

At our camp on the Río Blanco, twenty kilometers west-northwest of Piedras Negras, Veracruz, my companion, Jerrardo Mazza, and I (Dalquest) were told that small bats occasionally visited a nearby house in great numbers. We requested the persons who lived in the house to try and capture some of the bats. On the morning of May 13, 1946, two bats were brought to us and we were told that on the previous night the bats had been swarming at the house, alighting on the thatch of one end-wall. The two bats brought into camp had been knocked down with a bamboo switch.

I visited the house and found it to be of the ordinary kind, with roof and end-walls constructed of thatch of the fronds of the ivory-nut palm. On the ground at the outside base of one end-wall there was a considerable quantity of fresh droppings of bats. We lifted the thatch, a layer at a time, but found no bats. Seemingly the thatch was used as a resting place only at night. The early part of the next night was spent at this house, but no bats were seen, and we were told that the bats might not return again for several nights. Although the persons who lived in the house were asked to notify us immediately when the bats did return, they failed to call us. Nevertheless, when the bats next returned, on May 29, one of them was knocked down for us with a bamboo switch. The species was not detected again. One of the bats taken on May 13 was a pregnant female, the other a male. The one taken on May 29 was lactating.—WALTER W. DALQUEST AND E. RAYMOND HALL, *University of Kansas, Museum of Natural History, Lawrence, Kansas.* *Received September 9, 1947.*

A RECORD OF RED BATS MATING

Since there have been very few, if any, published observations of the red bat (*Lasiurus borealis borealis*) in the act of copulating, the following record, though incomplete, of a pair of these bats mating, is submitted.

As dusk approached on the evening of August 20, 1947, while fly fishing on Swan Creek Pond in Allegan County, Michigan, I noted a bat or bats in the vicinity, flying out over the water. Little attention was paid as to the number of them. A short time later as darkness was rapidly closing in, a single bat, as it seemed, suddenly tumbled onto the bank of the pond no more than five feet away squeaking loudly. It first seemed possible that the animal had struck at and been injured by the writer's artificial fly, but no unusual jerk on the line had been noted. A flashlight was immediately directed at the source of the noise where a single bat was expected to be lying. Instead, there lay on the bank a red bat which appeared to have one or more of its kind attached to it. The first thought ventured was that

a female might have young clinging to her, but when the animals were turned over and examined from all angles it was discovered that a male was clasped on the back of a female. Since this position undoubtedly had made it impossible for either to fly effectively, it seemed likely that the male had attached himself to the female in mid-air.

Neither bat showed undue concern about the light or about being turned and moved on the ground. The male held his position by hooking the enlarged nail of the fore limb over the front edge of the female's wing, with the posterior end of his body curved underneath the rear of hers. Both bats trembled with excitement as the male buried his head in the fur of the female's neck and attempted sexual contact. The penis of the male was protruded, but complete sexual contact was not observed.

An attempt was made to take the bats to the laboratory for photographing, a boot serving as a carrying cage, but unfortunately they separated when shaken out of the boot. They were no longer inclined to show interest in one another while in a cage at the laboratory. Further examination showed, however, that the testes of the male were descended and the area immediately around the genitals of the female was soiled and wet.

It was 8:21 P.M. when the bats were first observed on the ground; they had apparently remained in the mating position in the boot and separated when shaken out into a cage at 8:39 P.M.—FREDERICK W. STUEWER, *Game Division, Department of Conservation, Lansing, Michigan.* *Received October 26, 1947.*

NOTES ON SOME BATS FROM NEBRASKA AND WYOMING

During June and July of 1944, the writer was engaged as an assistant on a paleontological expedition to the badlands of northern Sioux County, Nebraska, and eastern Niobrara County, Wyoming. Working in the badlands provided many opportunities for becoming acquainted with the resident mammals, the most noteworthy of which were the bats.

The badlands of this region are composed of a very soft, easily eroded sandstone. On the sides of the bare stone ridges and along the high, exposed stream banks there were often sheets of loose stone in the process of being sloughed off, due to the rapid weathering of the rock. These sheets were usually about two inches thick and often bulged out from the bedrock to form pockets up to two or three square feet in extent. On June 24, a solitary male *Myotis s. subulatus* was found in such a pocket, less than a square foot in extent, in Antelope Township, Sioux County, Nebraska. On July 12, a solitary female *subulatus*, containing one fetus, was found in a similar situation in Sugar Loaf Township, Sioux County, Nebraska. On July 16, a single female *Myotis volans interior* was found in a pocket on the bank of S-Bar Creek in Niobrara County, Wyoming. These three bats are now in the collection of the Cleveland Museum of Natural History. Four other bats were discovered in like situations in the same region, but these could not be captured, since they immediately took flight when their retreats were discovered. In some pockets, white-footed mice, *Peromyscus maniculatus nebrascensis*, were found, and in a great many others, there were feces of either mice or bats.

The streamlets in the badlands, by lateral erosion, had often formed ledges and overhanging banks. Because of the weakness of the rock, the overhanging banks frequently developed deep cracks parallel to their edges. In one crack, in Warbonnet Township, eight miles north of Harrison, Nebraska, a colony of about 180 *Myotis volans interior* was discovered. Of the several dozen of these bats examined closely, all were females. Four that were dissected contained a single fetus each. It seems probable that many of the others contained young also. When disturbed, the bats dropped or crawled from the crack and flew in all directions to sooner or later drop into other crevices in the surrounding badlands. The next day, none of the bats were seen in or about the crack from which they had originally been disturbed. Other animals that were commonly found in the badlands, using similar ledges and cracks for nesting and shelter, were: *Peromyscus maniculatus nebrascensis*, *Neotoma cinerea rupicola*, and the Rock Wren, *Salpinctes obsoletus*. But for occasional cottonwoods, the badlands in which this colony of bats was located was practically treeless. The nearest place where there were trees in any number was the Pine Ridge, south about three miles. Here were dense cottonwood groves along the canyon

bottoms and open pine woods on the ridges. That a colony of this species of bat should be found in a fissure in a relatively treeless area, seems especially interesting, since Miller and Allen (U. S. Nat. Mus., Bull. 144: 138, 1928), in commenting on the little known habits of *Myotis volans*, state: "It seems to frequent open forest, ranging in summer to an altitude of at least 11,000 feet in the Sierra Nevada. Apparently it is not social to any great degree and in general it seems to avoid caves." So far as I have been able to ascertain, this bat has not been reported from Nebraska before, and this probably constitutes the first such record. Two bats from the colony were skinned and are now in the collection of the Cleveland Museum of Natural History.—W. B. QUAY, *Kinsman Road, R.F.D. #3, Chagrin Falls, Ohio. Received January 5, 1948.*

EXTENSION OF RANGE OF TWO SPECIES OF BATS IN FLORIDA

Records of bats from the portion of Florida south of Tampa Bay are rare. On April 13, 1947, a specimen of the yellow bat (*Dasypterus floridanus*) was collected by the author one mile northeast of Punta Gorda, Charlotte County, Florida. A number of individuals were seen flying about over a mango and citrus grove at dusk. The former southernmost record of this bat is Seven Oaks, Pinellas County, Florida—about sixty airline miles northwest of Punta Gorda.

One specimen of the evening bat (*Nycticeius humeralis*) was collected May 5, 1947, ten miles east of Punta Gorda. Individuals were numerous at dusk around pine groves in flatwoods. The two southernmost records of this bat are Indian Key, Pinellas County, Florida —about sixty miles northwest of Punta Gorda; and Kenansville, Osceola County, Florida—about eighty-five miles northeast of Punta Gorda.

Both specimens are now in the collection of Dr. H. B. Sherman, Department of Biology, University of Florida, Gainesville. The cited former records were taken from Sherman (Proc. Fla. Acad. Sci., 1936)—O. E. FRYE, JR., *Dept. of Biology, Univ. Fla., Gainesville, Fla. Received September 20, 1947.*

PORCUPINES IN SOUTHWESTERN ARIZONA

Taylor (Univ. Ariz. Biol. Sci. Bull. 3: 29–31, 1935) mentions several instances in which individual porcupines have wandered far from their woodland habitat. An extreme example of this instinct would be a porcupine seen by Mr. Geno A. Amundson and the writer in the Castle Dome Mountains of the Kofa Game Range in Yuma County, Arizona, on July 9, 1942. The animal was seen about 7:00 A.M., travelling along the ground in the vicinity of Bandy Tanks. These mountains, in one of the most uninhabited, arid, and hot sections of the desert southwest, support but a sparse cover of various xerophytic shrubs, cacti, and grasses, without a plant that could be called a tree. The closest approach to a tree would be the scrub oak, *Quercus dumosa* var. *turbinella*, which occurs sparingly. Airline distance to the nearest porcupine range (i.e., juniper–pinon woodland) would be about 120 miles. Considering the sluggish habits of the species, this would seem quite a distance to travel!

Since there are no records of the porcupine from the lower Colorado River, the following from the Bill Williams Delta, Havasu Lake National Wildlife Refuge, Yuma County, Arizona, are perhaps of interest: one seen December 20, 1943, two seen January 24, 1947, one seen February 4, 1947, and one seen November 24, 1947. Although in the hot Lower Sonoran, this locality is only about thirty-five miles from the nearest juniper–pinon woodland, and supports a considerable amount of cottonwood (*Populus Fremontii*) and willow (*Salix nigra* var. *vallicola*). The porcupine appears to be a more or less regular winter visitor in the area.—GALE MONSON, *Fish and Wildlife Service, Parker, Arizona. Received December 23, 1947.*

THE NUTRIA IN OHIO

What is apparently the first feral nutria (*Myogaster coypus*) from Ohio to be preserved is an adult male presented to the Ohio Wildlife Research Unit through the courtesy of the

Ohio Division of Conservation and Natural Resources. Dr. B. H. Talbut of Toledo procured it from Mr. C. A. Bradford of Whitehouse, Lucas County, Ohio. This ordinarily aquatic animal was found eating corn with the pigs, in Mr. Bradford's barn, when he killed it. Whitehouse is in northwest Ohio about twelve miles south of the Michigan state boundary and about seven miles from the Maumee River. The specimen, killed December 28, 1946, had the following measurements: total length 955 mm., tail 335, hind foot 127, ear 16, testis 30 x 20.

Reports have been received of nutrias being imported and released about ten years ago near Cleveland and a few Ohio fur farmers now keep nutrias both in pens and in small marshes. Mr. Merrill Gilfillan of the Ohio Division of Conservation and Natural Resources kindly wrote to Mr. Elmer Gemberling of near Kent, Portage County, Ohio, in this regard. Mr. Gemberling stated that a friend of his, about ten years ago, had imported several nutrias from South America and had penned them in a marsh in that northeastern county. These escaped, he said, during a flood and one was shot by a Mr. William Hill two years later in a pond a mile away. Definite records of importations into northwest Ohio, however, are lacking. Dr. William H. Burt of the University of Michigan writes that he has received several sight record reports of nutrias in Michigan, but has secured no specimens to date.—George A. Petrides and Daniel L. Leedy, *Ohio Wildlife Research Unit, Ohio State University, Columbus 10, Ohio.* *Received September 27, 1947.*

SIGHT RECORDS OF DALL PORPOISES OFF THE CHANNEL ISLANDS, CALIFORNIA

Records of the Dall porpoise (*Phocoenoides dalli*) in California waters are few, but indicate (Yocom. Jour. Mamm., 27: 367–68, 1946) that it may be a permanent resident near the Farallon Islands. The species has been recorded from near Santa Barbara Islands (see Benson and Groody, *op. cit.*, 23: 41–42, 1942, for summary of records). In my experience, this porpoise is rare in the Channel Islands, but I have seen it on several occasions in summer and it is pos ible that it is permanently resident there. The following extracts from my fishing log represent my observations.

July 6, 1936.—While scouting for broadbill swordfish, I sighted a group of Dall porpoises about two miles off Pyramid Head, San Clemente Island. There were some twenty individuals in the school. For the most part these porpoises would just break the surface of the water. However, occasionally, one or two would leap clear out exposing the brilliant white marking below and behind the dorsal fin. Their length ran between five and six feet. These porpoises were traveling about six knots and their direction was northerly.

June 27, 1939.—A group of about thirty was observed off East Point, Santa Rosa Island. These porpoises were moving toward the northwest up the Santa Cruz Channel. They were about five miles from the nearest land. Like the previous school, little interest was shown in the boat. While it was easy to observe them they did not come close enough for effective picture taking.

July 13, 1939.—A small school of ten or twelve was seen in the Anacapa Passage, between Santa Cruz and Anacapa Islands. These individuals were swimming very rapidly and were cutting back and forth through patches of bait fish such as anchovies and sauri. Also in this area were numerous schools of small tuna surfacing and feeding on the same bait.—B. L. Lustig, *948 Westchester Place, Los Angeles, California.* *Received October 20, 1947.*

THE FINBACK WHALE IN VIRGINIA WATERS

A sixty foot specimen of the finback whale, *Balaenoptera physalus* (Linnaeus), was collected near the United States Naval Amphibious Base at Little Creek, Virginia, by members of the Atlantic Fleet Detachment based there on April 3, 1947. The whale entered the Chesapeake Bay from the Atlantic Ocean and found its way through the entrance channel to Little Creek harbor on May 2, 1947. This channel is approximately four hundred feet in width. After entering the entrance channel it turned and grounded at high water on a shoal. Small boats were unable to clear the whale.

Captain E. R. Sperry, Commanding Officer of the Amphibious Base at Little Creek, said: "prior to grounding the whale *had not* been injured by collision with a ship or other such happening. At the end of the second day, May 3, by which time it was completely exhausted from its endeavors to free itself, it was shot. The whale was towed from the Little Creek entrance channel up the Elizabeth River to the plant of the Norfolk Tallow Company." J. W. Field, of the Norfolk Tallow Company, stated: "The whale measured sixty feet and weighed 42,310 pounds. In dissecting it we simply cut it up with knives and axes and used winches to convey the body into our plant, where it was manufactured into feeding material for animals, and the oil went into soap stock."

This is the second record for the finback whale in Virginia. The first was reported from Mobjack Bay, Gloucester County, in May, 1866, by Allen in 1869.—JOHN WENDELL BAILEY, *27 Willway Rd., Richmond 21, Va.* *Received July, 12 1947.*

MULE DEER RECORD FOR MINNESOTA

During the hunting season of 1947, Leonard Nygren shot a deer near Pillager, Cass County, Minnesota. The deer, which weighed 153 pounds dressed, was disqualified in a sportsman's contest because it was not considered a white-tailed deer, according to a newspaper report. The report was investigated and the animal in question was identified as a mule deer, *Odocoileus hemionus*. This extends the known range of this deer in Minnesota nearly 100 miles to the east. John Jarosz, Museum Preparator, and the writer went to Nygren's place nine miles north of Pillager and measured and skinned the animal which is now specimen number 2457 in the Minnesota Museum of Natural History collection. The total length of the animal was 72 inches, the ears were 10 inches, the metatarsal gland was 7 inches long, and the tail had a black tip. The vertical tine of the antler was not dichotomously branched, although quite long.

This is the first Minnesota record of a mule deer since 1941, when one was killed in Atlanta Township, Becker County, by a car. That specimen is number 1924 in the collections of the Minnesota Museum of Natural History.

Swanson, Surber and Roberts in "Mammals of Minnesota" (Minn. Dept. Conser., Tech. Bull. 2: 99, 1945) state, "The mule deer was found originally in western Minnesota at least as far east as northeastern Marshall County and possibly further, because it is a wide ranging animal."—HARVEY L. GUNDERSON, *Minnesota Museum of Natural History, Univeristy of Minnesota, Minneapolis, Minnesota.* *Received January 18, 1948.*

SEPTEMBER BIRTH OF A MICHIGAN WHITE-TAILED DEER

In the Grayling area of Michigan, most of the white-tailed deer (*Odocoileus virginianus*) fawns are born during the last week of May or the first two weeks of June. Each year, during deer hunting (rifle) season, which extends from November 15 to November 30, hunters report seeing spotted fawns in the woods. These are assumed to be late fawns since those born in May and June loose their spots in October.

The first authentic Michigan record for a September birth of a white-tailed deer was established September 13, 1947, when a male fawn was found by a motorist twelve miles east of Grayling. Several competent game men saw the fawn during the following two days, and all were of the opinion that it was two or three days old. This would place the date of birth at September 10 or 11. The fawn, first seen in the morning, was judged to be an orphan when it was still at the same location unattended that evening. It weighed six and one-fourth pounds when moved, September 15, to the Ogemaw State Game Refuge. Records from the Cusino Wildlife Experiment Station show the average weight of fawns at birth to be about seven pounds.

In his book, "The Mammals of Michigan," Dr. William H. Burt, writing of the white-tailed deer, states: "The rutting season . . . . reaches its height in November." And also, "The gestation period is 205 to 210 days." The time of mating was probably mid-February.

Experiments conducted at the Cusino Wildlife Experiment Station showed that does which were not bred during their first period of heat (usually in November) had a second

period approximately thirty days later, and a third period following that, if not bred during the second period. It therefore seems probable that this fawn's mother was not bred until she had come in heat the third or possibly the fourth time.

Late fawns may be the result of the unbalanced sex ratio existing in the Grayling area which allows some does to go through more than one period of heat without being bred, or they may be the offspring of yearling does that occasionally come into breeding condition for the first time in midwinter.—EARL J. GORDINIER, *Game Division, Michigan Dept. of Conservation.* *Received January 12, 1947.*

MOUNTAIN GOAT AGE RATIOS IN MONTANA

From July 1 to September 1, 1947, 132 mountain goats (*Oreamnos americanus*) were observed in their typical range above timberline on the high peaks in Glacier National Park, Montana. As white animals against darker backgrounds, they could often be seen at considerable distances, with few if any animals of a group hidden. They occurred singly and in bands of up to nineteen which, when approached closely, were seen to include both sexes.

In view of the limited data on reproduction in this species, notes were taken on the age ratio of this sample of the population. Though some of the animals may have been recounted on several occasions, this factor should not greatly affect the results. Of the goats seen, thirty-nine were young of the year as evidenced by their small size. The adult–juvenile ratio therefore was 93 :39, an apparently satisfactory condition.—GEORGE A. PETRIDES, *Ohio Cooperative Wildlife Research Unit, Ohio State University, Columbus 10, Ohio.* *Received October 9, 1947.*

ALBINO COTTON RATS

Recently the Biological Surveys Collection of the U. S. Fish and Wildlife Service received two juvenile male albino cotton rats (*Sigmodon hispidus hispidus*) from the Office of the U. S. Public Health Service at Thomasville, Georgia. Both specimens were collected by H. B. Morlan in Brooks County, Georgia, one on August 20 and the other on September 16, 1947. Edwin V. Komarek, who obtained these specimens for us, stated that they are the first that he had ever seen. Dorr D. Green, Chief of the Division of Predator and Rodent Control, U. S. Fish and Wildlife Service, states that these are the first records known to him.—MARSHALL C. GARDNER, *U. S. Fish and Wildlife Service, Washington 25, D. C.* *Received January 15, 1948.*

MICROTINE AQUATICS

On a September afternoon, a class of zoology students on the look out for salamanders one mile north of Indiana, Pennsylvania, reached a little pool about twenty feet wide and forty feet long. Second growth woods was on one side and on the other was a scrubby growth along a railroad cut, definitely an unlikely place for *Microtus*. At the upper edge of the pool an old rotten log projected a few feet into the water. Two of the students ventured out on the log, the better to look for newts, but on reaching the end a sharp exclamation arrested the attention of everyone.

A small mammal had leaped into the water and, swimming a few inches below the surface, was making for the shore about twelve feet distant. As it traveled under water it gleamed as though coated with quicksilver, like a diving beetle, from the film of air surrounding it. It moved not only with vigorous leg action, but with a rapid, jerking motion of the body as though trying to gallop beneath the water. After about an eight foot submergence it came to the surface and swam toward shore, but, upon discovering the writer it lodged itself at the base of a two-inch willow where a few water plants grew. On being disturbed, it submerged and headed back toward the end of the log. Baffled by the humans, it hid in a small patch of grasses projecting from the water a couple of feet from the end of the log. Disturbed after a rest of a minute or two, it again set out under water for the first landing point about twelve feet away. About two feet from shore it came to the surface

and swam to its previous hiding place. Again it was given a short rest, then on being disturbed it set out on the underwater journey back to the log, coming up a couple of feet off the end and hiding in the grass patch. After a short rest it was once more punched out and again swam for the same point on shore, going most of the way, as before, below the surface. This time it gave indications of wanting to come to shore regardless, but finally took refuge beside the small willow. After another short rest it was stirred out and swam for a couple of feet on the surface; its fur showed signs of becoming wet. Then it submerged and came up under the end of the log. Here it made for the shore and was captured. The under-water swimming must have totalled better than fifty feet.

This first swimmer had hardly been caught when another leaped from the end of the log and started swimming away. It circled after going about a yard, kept to the surface, and made for the end of the log where it promptly landed and was as promptly caught. Both specimens were *Microtus pennsylvanicus*. About one hundred feet or more away along a railroad cut was an occasional sparse growth of grass, but there was no microtine country within about a quarter of a mile.

My other observation of the meadow mouse in water dates back to my boyhood when an occasional summer cloudburst would temporarily flood a little meadow in the Virginia mountains. Several times while wading in the shallower flood waters I encountered bedraggled meadow mice struggling in the water or clinging, wet and shivering, to a small bit of driftage. Once I recall collecting some five or six half-grown individuals that looked about done for. I carried them home in a tin can which was placed near a fire. I believe all revived as they became dry and warm and were then released outside.

Blair (1939, Jour. Mamm., 20: 375) reported a Michigan meadow mouse in a swamp pool, swimming freely for about ten feet below the surface. Audubon and Bachman (1854, Quadrupeds of N. A.), in writing of Richardson's meadow mouse, said that it could swim and dive well and that all meadow mice were capital swimmers.—THOMAS SMYTH, *Department of Biology, University of Florida, Gainesville.* *Received February 14, 1947.*

RED SQUIRREL NESTING ON THE GROUND

On June 14, 1947, ten miles southeast of Mio, Oscoda County, Michigan, Josselyn Van Tyne and I discovered the nest of a red squirrel (*Tamiasciurus hudsonicus*) on the ground at the base of a small jack pine. Our attention was drawn to this nest by the sudden appearance of an adult squirrel as my hands parted the sparse growth of blueberries at this point. It was not until after I had felt the resilience of the surface above the nest that I noticed a small entrance hole situated against the trunk. The nest was constructed of grass and was set snugly in an oval depression. It was overlain with a thin layer of oak leaves which covered the ground at this point. In the nest, there were four young about two-thirds adult size. The one young squirrel examined was covered with fur, but its eyes were closed and it offered no resistance to my handling.

The terrain here is rolling, and the forest was burned some years ago. The land now bears a scattered growth of jack pine, averaging about fifteen feet in height, with a sprinkling of scrubby black oak. Red squirrels are distributed rather generally throughout the area. Although tree nests have been seen, they are not numerous. This circumstance suggests the possibility that ground locations may be common nesting sites here. However, this nest was so well concealed that others similar to it would seldom be found without careful search.—HAROLD MAYFIELD, *2557 Portsmouth Avenue, Toledo, Ohio.* *Received October 8, 1947.*

JACK RABBITS EXPERIENCE A POPULATION "HIGH" IN THE TRANS-PECOS REGION, TEXAS

Observations, made May 7 to 9, 1947, indicate that jack rabbits (*Lepus californicus* ssp.) in the vicinity of northern Brewster County, Trans-Pecos region of Texas, are experiencing a "high" in population. Reports made by residents to Helmut K. Buechner indicate that the animals have been building up to the present maximum over the last four or five years.

On May 9, 1947, a quantitative check of population was made on certain highways in the vicinity. Dead jack rabbits occurred at the rate of 2.36 per mile in Brewster and Pecos counties, between Highways 90 and 290, on Highway 67. Farther east, in Pecos County, Texas (Highway 290), dead jack rabbits per mile occurred at the rate of 3.20. Still farther east on the same highway, jack rabbits were not nearly so numerous, occurring at the rate of only .46 dead animals per mile; and the same highway between Sonora, Sutton County, and Junction, Kimble County, showed but .06 jack rabbits per mile.

All these localities were in the Ector Rough Stony soil group of the Edwards Plateau, except Highway 67 which at this point is merging toward the Basin and Mountain type of soils and vegetation. Note that between Sonora and Junction, fifty miles of highway, there were only .06 dead jack rabbits per mile. Here the vegetation is made up of live oaks and grasslands rather than mesquite and desert shrubs only. It is obvious that there are marked differences in the jack rabbit population even in different portions of the desert shrub type. When one leaves the strictly desert shrub and enters the live oak savannah, there is a still more striking difference.

Thus, while the jack rabbit population is at a relative high in portions of Brewster County, Texas, and doubtless in other parts of the Trans-Pecos, this maximum population does not extend over more than a limited part of the area. Evidently the conditions which govern the fluctuation in numbers are different within a comparatively short range of country even where the soil and vegetation types are much the same.—WALTER P. TAYLOR, *Texas Cooperative Wildlife Research Unit, College Station, Texas.* *Received August 12, 1947.*

WHO TRIMS THE CREOSOTE BUSHES?

Anyone who wanders widely over the southwestern American deserts may have noticed, especially in late summer and autumn, many creosote bushes (*Larrea divaricata*) showing evidence of trimming of several of the smaller green branches, particularly those near the ground. The branches cut are usually no larger in diameter than those of an ordinary lead pencil and the trimmings are seldom longer than eight or ten inches. Twenty or thirty branch ends may be severed from a single creosote bush so that there is a considerable litter of leafy twigs underneath. In almost every case they are cleanly cut off at an angle, so smoothly that the cut almost has the appearance of having been made with the aid of a sharp jack-knife. Close examination will generally reveal the marks of paired teeth, showing that the work has probably been done by rodents. The question is, which ones. The evidence is strong that most of it is done by black-tailed jack rabbits (*Lepus californicus deserticola*). One almost invariably finds quantities of fecal pellets of the hare below the site of trimming and the stems are bitten off no higher than the hare can reach while standing on its haunches. Two of my correspondents tell me that they have actually seen jack rabbits biting off the twigs in late evening just before darkness. The fact that this cutting of creosote twigs is so common and that so few people have ever seen the work being done is certainly good evidence that it is done by nocturnally or crepuscularly active rodents. One wonders what is the purpose of this activity on the part of the hares and why it is that they almost invariably choose to work on *Larrea*. In the area there may be many other shrubs such as *Lycium cooperi*, *Franseria dumosa*, *Krameria canescens* and *Hymenoclea salsola*, but I have never, in twenty-five years of observation of this phenomenon, found similar trimming of these shrubs.

In September, 1945, while walking along a half mile of a lonely abandoned miners' road on the southern Mohave Desert, I counted over fifty creosote bushes which had been recently trimmed in this manner. In some cases there was an almost complete circle of dried or half dried leafy twigs around the perimeter of the bushes. The only explanation I have to offer is that the hares do this work to sharpen their teeth. There is always the possibility that small sections of the stems are eaten. I sent pellets gathered from beneath trimmed creosote bushes to Dr. Tracy I. Storer, University of California, but he was unable to determine the presence of *Larrea* in them because the vegetable components were so finely comminuted.

For a time I was convinced that rabbits or hares were responsible for all the trimming, but a number of times recently I have found bushes from which twigs were removed at points higher than any hare could reach. In two instances I have traced this high trimming to the activity of woodrats (*Neotoma*) which had built up collections of stones and sticks as well as creosote twig ends about the entrance to their underground abodes.—Edmund C. Jaeger, *Riverside, Calif. Received September 26, 1947.*

A CHEST FOR DERMESTID CLEANING OF SKULLS

Having read with much interest Russell's report (Jour. Mamm., 28: 284–87, 1947) on management of dermestid beetles for skull cleaning, it seems that the design of a "bug box" which we have operated for some time may be of interest to other mammalogists.

This chest, designed and built several years ago after a visit to the "bug room" of the Museum of Vertebrate Zoology, described by Hall and Russell (*op. cit.*, 14; 372–74, 1933), was our attempt to provide dermestid skull-cleaning facilities for a department in which the capacity of a special room is not needed, and the expense is not justified.

Russell says (*loc. cit.*: 286), "A box 36″ x 24″ will accommodate a large colony." By coincidence, these are the precise horizontal dimensions of our box, the capacity of which has proven more than ample for our needs. It is eighteen inches in depth. Constructed of 22-gauge galvanized sheet iron, it has a close-fitting, hinged lid with hasp and staple for locking. The lid extends down one inch over the top edge of the box. The top edge, inside, carries an inturned flange one inch in width, covered with a one-inch strip of sponge rubber. Thus is provided a bug-tight outer cover.

Within the box, three inches below the top edge, is a horizontal metal partition and lid, the equivalent of a double entrance door to a bug room. The major portion of this partition, however, is a lift door, or lid, 1 ft. 9 ½ in. x 2 ft. 9 in., covering a central opening in the partition about two inches smaller in each dimension. In other words, the partition, exclusive of this lid, is only a horizontal rim of galvanized iron extending around the wall of the chest fifteen inches above the bottom. This lid is hinged by one edge to the rim at the back and held down flat by turn button clamps at the front edge. It overlaps about one inch and rests on a one-inch strip of sponge rubber as does the outer cover. In the center of this large lid is another, smaller opening, covered by another hinged lid 9¾ in. x 13½ in., with ⅝ in. overlap, cushioning strip of sponge rubber, and turn button clamps. This smaller lid consists entirely of brass gauze save for the necessary supporting frame of solid metal ¾ in. wide. Thus, in the interest of keeping the dermestids confined, there is provided a smaller entrance into the box; one which it was thought would be desirable for use when the larger opening was not required. After experience with this box, the small opening is not considered essential. The inner partition does provide against any of the insects lying immediately under the outer cover, whence they might readily escape as the box is opened.

In each end-wall of the chest, above the horizontal partition, is a 2½ in. x 20 in. opening in the galvanized iron, over which is soldered a covering of fine brass gauze. These gauze-covered openings in the ends, above the partition, and the gauze inner lid in the center of the partition provide sufficient ventilation without much light penetration. The box is most likely to be kept in some dark corner, in any case. The bugs work better with additional coverings of cotton, cloth, or tissue paper, even in relative darkness. Hence the light penetration is not serious.

Without the careful experimental technique described by Russell, we have had increasingly good results with our venture as the bugs have become better established, and as we have learned by slowly won experience some of the things he emphasizes. It does not at this time appear probable that we shall have to follow the roasted sheep tongue method of feeding to keep a sufficient supply of bugs for our needs. So far we have done quite well on a rather haphazard schedule—just trying to see that they never starve out. The matter of temperature in our climate gives us no concern save to see to it that the box is not exposed to extreme heat. Year in and year out it stands in a corner of a laboratory which

is not air-cooled in summer and which does not have the coolness of a basement room or even of a first floor location. The temperature range is between about 70° to 85–90° F. We can doubtless improve the speed of our process somewhat by heeding suggestions in the two papers referred to. Results, however, are excellent as we now operate.

Another item of different character deserves mention; it concerns the species of dermestid used. The Museum of Vertebrate Zoology uses *Dermestes vulpinus*. Our work was started with whatever dermestids came handy and at least two quite different kinds, possibly more, have been introduced. Without having made specific determinations, it is believed that *D. vulpinus*, or a species of that size and general appearance, was introduced at least once. Possibly also an even larger species was once introduced. The dominant dermestid in our bug chest now is a species of *Anthrenus*, apparently *A. varius*. It is of similar appearance, but slightly smaller than its too-well-known relative, the carpet beetle, or buffalo moth, *Anthrenus scrophulariae*. The latter may also have been introduced.

As we reflect upon our experience and results in conjunction with those of the M.V.Z. workers, we are inclined to believe that, for our operations, which are limited in quantity and confined mostly to the smaller skulls, our smaller dermestids may be preferable. The smallest and most delicate skulls that we have had cleaned by our bugs, such as those of small bats of the genus *Myotis*, have remained for weeks in the bug chest without harm and the cleaning job has been absolutely perfect. Many such skulls are perfect without the ammonia treatment recommended by Hall and Russell (*loc. cit.*). In fact, to date we have not used the ammonia follow-up though in some instances it would be advantageous, but we shall use it hereafter when desirable.—CHARLES T. VORHIES, *Department of Entomology and Economic Zoology, University of Arizona, Tucson, Arizona.* *Received October 23, 1947.*

DEEP FREEZER FOR PRESERVING SPECIMENS

The collector of small mammals often finds it inconvenient to prepare all of the skins at the same time. A great help in overcoming this situation is the deep freezer that is finding its way into more and more homes. With very little trouble, specimens can be frozen until wanted. I have had a *Microtus p. pennsylvanicus* in the freezer seven days and a *Peromyscus m. maniculatus* fourteen days before skinning. Both of these specimens skinned out very easily; the feet and tail were not dry. The longest period for which any specimen was frozen was twenty-one days. There are few cases where specimens would need to be frozen for longer than a month, but they could be kept in a frozen state almost indefinitely. In preparing the specimens for the freezer, I use a cellophane bag that is manufactured for freezer use. The top of the bag is sealed with a hot iron. The bag keeps the specimen from drying out if it is to be left in the freezer for more than a few days. A label is also placed inside the bag for identification. I also found that if mammals starting to spoil are frozen for one to two days and then skinned the odor is hardly noticed. When a specimen is wanted, it is put in room temperature for a few hours. As soon as the outside layer of flesh is unfrozen the specimen is ready to be skinned. Specimens cannot be re-frozen without great danger of spoilage.—DONALD H. DEMEULES, *2216 Thomas Ave., North Minneapolis 11, Minn.* *Received September 2, 1947.*

REVIEWS

Bailey, John Wendell. THE MAMMALS OF VIRGINIA. Privately published. Williams Printing Co., Richmond. Pp. xvi + 416, 96 figs. 1946. Price, $5.00.

This volume is the result of fourteen years intermittent study of the mammals of Virginia while the author was teaching at the University of Richmond. Eighteen chapters record mammalian characteristics, the history of Virginia mammalogy, geologic history of mammals, fossil mammals of the States, habits of modern mammals, economics, conservation, classification, identification, type localities, a classified list, an account of the recent land mammals of Virginia, gestation period of certain mammals, a bibliography, and index. A notable feature of the volume is its redundancy; the material in chapters 11 to 13, is repeated in Chapter 15.

Much extraneous matter is interpolated in the pages of this book. Why a resumé of game bird propagation, a listing of whites and negroes by counties, and short but irrelevant quotations, occupying the larger part of several pages, are inserted is difficult to understand. The imposing list of 768 titles in the bibliography are by no means all quoted. Moreover, many which are relevant to the subject have apparently not been digested, otherwise the numerous errors would obviously not have occurred. Titles are recorded through 1944, yet only 7 per cent are listed from 1936 until the manuscript was completed. The past decade has provided a wealth of material on the habits of mammals; many papers which have appeared are far more pertinent to the subject matter than those which are quoted.

One reads that the number of teeth are always constant in each species. Those who have studied carnivores will not agree with this statement. While Hartman's publications on *Didelphis* are listed in the bibliography, the statement is made that the opossum places her newborn young in the pouch. A number of species are listed which have not been recorded from the state. Problematical forms might preferably be treated in an appendix, with the nearest known locality and a brief description of the species. A great deal is presumed re the habits of mammals. As an example, Bailey reports (p. 107) the nests of *Blarina* and *Microtus* very similar, yet the initiated will recognize at a glance the marked difference. Since the habits of the various subspecies are repeated, oftentimes in almost identical words, it would have been desirable to group the subspecies under the species, relating any minor subspecific differences in habits that might be known. Much was known on the breeding habits of bats, particularly *Myotis*, when this volume was in preparation, but the author dismisses this knowledge with the statement that such exact information is not known. One must question whether *Myotis* and *Pipistrellus* carry the young with them for ten days or two weeks following birth. *Lasiurus* rather than *Nycteris* is currently accepted as the generic name of the red and hoary bat. The oft repeated statement is made that the raccoon washes its food before eating whenever possible. Captive specimens will dunk bread in water, but probably only to soften such food; the wild animal seldom washes its food. Indeed, the nature of the food often prohibits this. It is stated (p. 138) that the fisher mates in February and March, the young being born in May. It has been established for some time that mating follows partus by a week or ten days. Much of the habits of the species treated are apparently gleaned from Goodwin's "Mammals of Connecticut." Had Bailey examined study skins or fresh material he would not have made some of these errors. The black tail tip of the New York weasel is never one-half the length of the tail, nor does the least weasel normally possess a black tail tip. Pages 160–170 are devoted to the breeds and habits of the domestic dog and cat. Habits of the two subspecies of *Tamias* are not so dissimilar as indicated, and might well have been lumped together. The young of the red squirrel are said to be born in May or June, the mother caring for them until late summer or early fall. It is well known that two litters are the rule and the young shift for themselves shortly after leaving the natal nest. While Sollberger's account of the flying squirrel is listed in the bibliography, Bailey implies that the number of litters is still unsettled. The field mouse, *Microtus p. pennsylvanicus* is credited as beneficial through destruction of insects and soil turnover, but no mention is made of its extensive

damage to fruit trees. This damage, rather, is credited to *M. p. nigricans*, which occupies a limited area in the coastal plain region. If the muskrat "in preparation for winter . . . store up roots and vegetable matter," then Dr. Bailey should enlarge on these observations and record them more fully elsewhere. *Rattus* and *Mus* are stated to have a gestation of twenty-five days (p. 256 and 259). In *Rattus* the gestation of primipara females varies from 21–23 days; it may be lengthened a week or more in pregnant females which are suckling young. Whether the fisher is the only wild animal which can handle the porcupine (p. 269) is debatable. Bailey states that there is no authentic record of the varying hare for Virginia, yet it has been taken in Highland County. Ten pages are devoted to the bison, which was last recorded as a Virginia native in 1797. Eighteen pages are accorded cattle, horse, and mules. To the latter, the author has coined the trinomial *Equus caballus assinus*, a name which, I hope, will not gain wide usage.

The arrangement of the recent mammals in this work is stated to be based on Miller's 1923 check list, but Bailey has taken liberties, giving man the exalted position at the "top of the list." The book closes with a list of publications by the author and those in manuscript or preparation. The latter include a proposed report on the amphibians and one on the reptiles of Virginia. It is hoped that Dr. Bailey will send the completed manuscripts to some capable herpetologist for final reading. Such apparent errors in nomenclature as appear on page 229 of the present work (timber rattlesnake= *Crotalus atrox*) and the palpable mistakes which are so frequent in this volume will thus be minimized.

A short autobiography on the jacket includes educational attainments and war record, summarized by a list of citations and awards. The author is pictured on the frontispiece. —W. J. Hamilton, Jr.

Handley, Charles O., Jr. and Clyde P. Patton. Wild Animals of Virginia. Commonwealth of Virginia, Commission of Game and Inland Fisheries, Richmond. Pp. vi + 220, figs. 103, including numerous maps. 1947. Price, $3.50.

This is a small volume, a contribution of the Virginia Cooperative Wildlife Research Unit: The Commission of Game and Inland Fisheries, the Virginia Polytechnic Institute, the Wildlife Management Institute, and the United States Fish and Wildlife Service.

Following a short introduction, a section is devoted to methods of studying the state mammals, then follow discussions of game mammals, furbearers, rodents, insectivorous mammals, marine mammals and vanished mammals. Late records of the recently extinct species are well documented. Many readers will be astonished to learn that the elk, restocked in Virginia in 1917 and again in 1935, eventually became a nuisance to farm crops necessitating a strict reduction in the herd. In 1944, a four day open season resulted in the killing of more than sixty animals. Virginia may have the distinction of being the only eastern state in which the elk is a game animal, but the farmer-sportsman relation may suffer. The practice of reintroducing big game species into the agricultural states of the east is questionable.

The natural regions of the state are mapped and mammals characteristic of these areas are listed. A check list of the Virginia wild mamals includes 109 species and subspecies, some now extinct and others known only from contiguous states. A short key takes the mammals to their respective orders. The remainder of the book (pp. 99–206) contains a systematic account of the various species, including the scientific and common name, type locality, distinguishing characters and measurements, the general range, and its distribution in Virginia. For each mammal there is an outline map indicating the counties from which the species has been recorded. An adequate bibliography and a suitable index complete the volume. Since the authors do not speculate on the habits of mammals, but accept the writings of recent investigators and their own field observations, there are notably few errors. Like others in the past, they venture the opinion (p. 59) that the pine mouse, trespassing the subterranean tunnels of the mole, accounts for the principal damage to vegetation. Such has not yet been demonstrated; we know that the large *Scapanus* of the western states may do extensive damage to bulbous plants. Perhaps

our eastern *Scalopus* is not without blame! The decline of the marten and fisher is attributed to their long gestation period (p. 86). This belief has been held by many authors. In reality, regardless of the length of the gestation period, the killing of a female of a monoestrous species represents the loss of a potential litter the following summer. The blue whale, mightiest of all beasts, is credited with subsisting on the smallest items of food consumed by any mammal (p. 64). I doubt if the krill, however small, can approximate the tiny insects eaten by some bats and shrews.

The present volume should stimulate the young naturalist and will certainly act as a foundation for future work. It would be desirable, in future printings, to add a short account of the habits of the better known species.—W. J. Hamilton, Jr.

Skinner, Morris F. and Ove C. Kaisen. The Fossil Bison of Alaska and Preliminary Revision of the Genus. Bull. Amer. Mus. Nat. Hist., Vol. 89, art. 3, pp. 127–256, 25 tables, 5 figs., pls. 8–26, 3 maps. Oct. 31, 1947.

This important contribution is one of the few attempts which have been made to bring order out of chaos in one of the large groups of Pleistocene and Recent Holarctic Mammals. The study represents much careful and detailed work on the part of the authors during a number of years. The study began as a report on the remarkable series of extinct *Bison* remains collected by the Frick Laboratory, the American Museum of Natural History, and the Alaska University, in the vicinity of Fairbanks, Alaska. This report grew, through the years, to monographic proportions to include the consideration of thirty-two named American and thirty-three named Eurasian species and subspecies of *Bison*.

In addition to the bringing together and reassemblage of the extensive literature on *Bison*, the work involved a careful study of hundreds of specimens, including types, in North America. There is a complete synonymy and list of references. A chapter devoted to *methods* explains all terms used, gives definitions of horn-core indices, shows comparative views and scales used in the text, and explains, with illustrations, cranial measurements employed. They present a simple standard for measurements and for illustrations which will simplify the interpretations of *Bison* crania. A system of wear classification for the teeth of *Bison* is included and is illustrated by six plates containing ninety figures.

They found that male horn-cores and skulls are diagnostic of the different species and subspecies. Specimens of female *Bison* are so poorly represented that they could not be used, with certainty, in much of the study.

The authors have been very conservative in their interpretations. They recognize six subgenera of *Bison*, based on the study of crania and horn-cores. Three of the subgenera, *Platycerobison*, *Gigantobison* and *Parabison*, are introduced as new terms. "Four of these subgenera (*Bison*, *Simobison*, *Superbison* and *Platycerobison*) were common to both the Western and Eastern Hemispheres, one (*Gigantobison*) apparently was confined to North America alone, and one (*Parabison*) to Eurasia." Ten of the thirty-two previously named species and subspecies of *Bison* from North America are recognized as valid and two new species are named. The twelve recognized kinds are: *Bison* (*Bison*) *bison bison* (Linnaeus); *B.* (*B.*) *b. athabascae* Rhoads; *B.* (*B.*) *occidentalis* Lucas; *B.* (*B.*) *preoccidentalis* Skinner and Kaisen, known only from late Pleistocene deposits near Fairbanks and Kotzebue Sound, Alaska; *Bison* (*Simobison*) *antiquus antiquus* Leidy; *B.* (*S.*) *a. figginsi* (Hay and Cook); *B.* (*S.*) *alleni* Marsh; *Bison* (*Superbison*) *crassicornis* (Richardson); *Bison* (*Platycerobison*) *chaneyi* (Cook); *B.* (*P.*) *geisti* Skinner and Kaisen, known only from the late Pleistocene deposits near Fairbanks, Alaska, and northern Canada; *B.* (*P.*) *alaskensis* (Rhoads); and *Bison* (*Gigantobison*) *latifrons* (Harlan).

Thirteen of the thirty-three previously named species and subspecies of *Bison* from Eurasia are recognized as valid and one new subspecies is named. They are as follows: *B.* (*Bison*) *bonasus* (Linnaeus); *B.* (*B.*) *occidentalis primitivus* (Hilzheimer); *B.* (Subgenus?) *sivalensis* Lydekker; *B.* (Subgenus?) *palaeosinensis* Chardin and Piveteau; *B.* (*Parabison*) *ex*[*i*]*guus exiguus* (Matsumoto); *B.* (*P.*) *exiguus curvicornis* (Matsumoto); *B.* (*P.*) *exiguus*

(?) *harbinensis* Skinner and Kaisen, "holotype *Bison* species a, Tokunaga and Naora, 1934, from Ho-chia-kou, 5 kilometers southwest of Harbin, Manchoukuo; reported as middle Pleistocene;" *B.* (*P.* ?) *schoetensacki schoetensacki* (Freudenberg); *B.* (*P.* ?) *s. mediator* (Hilzheimer); *B.* (*P.*) *s.* (?) *maior* (Hilzheimer); *B.* (*Simobison*) *cesaris* (Schlotheim); *B.* (*S.*) *priscus* (Bojanus); *B.* (*Superbison*) *crassicornis* (Richardson); and *B.* (*Platycerobison*) *pallasii* (Baer).

A list of invalid *Bison* names is included.

No attempt is made to assign the *Bison* remains of North America to glacial or interglacial stages because of the poorly known Pleistocene stratigraphy of the continent. *Bison chaneyi* (Cook), one of the "flat-horned bisons" is considered as the oldest *Bison* in North America, having been taken presumably from early Pleistocene deposits. Early Pleistocene is defined (p. 132) as "from the close of Pliocene to the close of the Aftonian." *Bison latifrons* (Harlan) is considered as having been taken from middle Pleistocene and *Bison alleni* (Marsh) from middle to late Pleistocene deposits. Middle Pleistocene is defined as the "close of the Aftonian to the middle of the Illinoian." This is certainly in keeping with what is known of the Pleistocene deposits from which these forms were taken.

Bison preoccidentalis is considered the progenitor of *occidentalis*, which in turn is the progenitor of *B. b. athabascae* and *B. b. bison*. It seems that we have here a series of specimens that shows both vertical and horizontal subspeciation. *Bison alleni* is considered as the probable progenitor of *Bison antiquus*. Evidence for this is based upon retrogressive horn-core growth as observed in the above subgenus *Bison*. It is best to quote directly from the authors, "Evidence suggests that the descendants of *alleni* were subjected to the same process of retrogressive horn-core growth observed in the line of retrogression in *B.* (*Bison*) *preoccidentalis*, *B.* (*B.*) *occidentalis* and *B.* (*B.*) *bison* (pl. 14). In the case of *alleni* the descendants appear to be the species *B.* (*Simobison*) *antiquus* which has many of the retrogressed attributes of *alleni* (compare pls. 15, 16)"

Conclusions are given both in German and French.

The authors should be congratulated upon their excellent work, and Mr. Childs Frick should be highly commended for his great interest in Vertebrate Paleontology which has made this publication possible.—CLAUDE W. HIBBARD.

Gates, R. Ruggles. HUMAN ANCESTRY FROM A GENETICAL POINT OF VIEW. Cambridge. Harvard University Press. xvi + 422 pp., illustr. January 26, 1948. Price, $7.50.

In this interesting and somewhat thought-provoking book, Professor Gates has assembled and re-interpreted the scattered information on fossil primates. The mammalogist who is not primarily interested in primates will probably confine his reading to Chapters 2, 11, and 12. Chapter 2, *Principle of Parallel Evolution*, contains evidence from various groups of animals to demonstrate a principle which Gates stresses throughout the book—parallel evolution and parallel mutations. To quote (p. 18): "A real difficulty in the construction of phylogenetic 'trees' is that the diverging branches and twigs of a tree inadequately represent what takes place in the evolution of any group or phylum of organisms. They represent the divergent variations, but take no account of the equally numerous parallel mutations." With this, the reviewer heartily agrees. In discussing the lower categories in the classification of animals, he stresses the time element. On page 21 he says: "The genera will thus be determined on a time basis and the species will be classified on the basis of their spatial distribution. Thus in the paleontological record a species belonging to one genus often passes directly into a species of another genus (but belonging to the same lineage), whereas the branching of one twig or lineage may result in the production of several contemporaneous species of the same genus."

Chapter 3, *Evolution of the Mammals*, might better have been titled *Evolution of the Primates*—that is what it is. In Chapter 11, *Some Principles of Speciation in Primates*, he argues against using the sterility factor in distinguishing species. He re-states his view (p. 366) that "the main primary 'races' of mankind should be recognized as species."

Further, he says that "The evidence is clear, however, that the primary so-called races of living man have arisen independently from different ancestral species in different continents at different times." This differs radically from an interpretation by Hall (Jour. Mamm., 27: 358–64).

Chapter 12, *Paleontology, Speciation, and Sterility*, is pretty much a crystalization of the main theme of the book—sterility is of little or no value in the designation of "species," instead, they " . . . should be founded primarily on morphological differences." (p. 393, footnote). This chapter contains a critical discussion of the problem of speciation. Some may not agree with Gates on all points, but whether they agree or disagree, they will perforce be stimulated by his provocative argument.—W. H. Burt.

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENT AND NEWS

NORTH AMERICAN CENSUS OF SMALL MAMMALS

Data from many sources indicate that trends of change in the dynamics of the populations of many animals tend to be cyclic. In addition there is a tendency for the stage in the population cycle for a species to be in phase over wide geographic areas. The Rodent Ecology Project is sponsoring the initiation of a cooperative program using a standardized sampling technique to investigate this problem further. Emphasis is placed on the sampling of small mammals such as *Microtus*, *Sigmodon*, and *Peromyscus*. Prospective cooperators and others interested in this program may receive a detailed description of it by writing JOHN B. CALHOUN, *Rodent Ecology Project, Johns Hopkins University, 615 North Wolfe Street, Baltimore 5, Maryland.*

EUROPEAN RELIEF

Don't forget your colleagues in Europe. Continued aid through the summer will assure receipt, in Europe, of clothing and food before another winter.

SUBSIDY

Illustrations for the article by Gould and Kreeger were subsidized in part.

DATE OF ISSUE

Vol. 29, No. 1, Journal of Mammalogy, Mailed **February 13, 1948**

Space was provided in the last number to write in the above date.

FRANCIS BEACH WHITE

A Charter Member and Life Member of the American Society of Mammalogists, Francis Beach White died at Brattleboro, Vermont, January 16, 1948. He was born August 20, 1872.

ALDO LEOPOLD: 1887–1948

The sad news of Professor Leopold's death on April 21, 1948, reached us just before going to press. Professor Leopold was an outstanding authority on problems of wildlife and conservation. His influence is felt wherever Wildlife Management is being taught or practised He contributed much to this field as well as to the general field of biology His multitude of friends will miss him, but they won't soon forget his charming personality, his enthusiasm, or his forceful way of presenting his ideas. He was a man who lived, and enjoyed, a full life. It was good to have known him—it will be good to remember him.